INTEGRATED PEST MANAGEMENT PLAN

NEZ PERCE NATIONAL HISTORICAL PARK

AND

BIG HOLE NATIONAL BATTLEFIELD

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EXECUTIVE SUMMARY

The Integrated Pest Management (IPM) Plan for Nez Perce National Historical Park (NEPE) and Big Hole National Battlefield (BIHO) promotes the goals of the Servicewide IPM program and is intended to sustain the health and safety of park staff, visitors, and residents, and to protect the cultural and natural resources of the park. This IPM Plan was assembled to provide basic resource information and guidelines in pest management. New information becomes available continually and it is imperative that this plan be reviewed and updated as needed. Continual use and revision will make this plan valuable as a management guide and resource tool.

The Superintendent has ultimate responsibility for pest management within the park and according to this plan designates the park Chief, Resource Management to serve as the park IPM Coordinator. This position will direct and implement the park IPM program as outlined by NPS-77, Natural Resources Management Guidelines (September 1991).

All pesticides used at NEPE will be in accordance with Servicewide policy found in NPS-77, Natural Resources Management Guidelines, and revised IPM program procedures (1994). Pesticides used in the park (except those used for personal use by park residents) will be applied by or under the direct supervision of a certified pesticide applicator. Pesticides used by residents, contractors, concessionaires, special-use permittees, agricultural lessees, or any non-NPS personnel in the park will conform to NPS policies and guidelines and must receive approval prior to use. It is a goal of NEPE, in compliance with NPS policy, that the least toxic pesticides will be used.

There will be no "preventative" pesticide treatments made in the park, unless prior NPS approval is obtained. Preventative applications will be considered to be "application of a pesticide in the absence of a target pest" and, as such, a violation of Federal law.

The IPM Coordinator will compile treatments, using the NPS IPM software (PUPS) and forward a copy to the CCSO at the end of each calendar year. Use of pesticides by employees in residences or for personal use must conform with established Service policies, guidelines, and approval processes and are exempt from year end reporting processes.

Pests at NEPE have been divided into two basic zones of management. These zones are structural and landscape. Within the structural zone are interior and exterior structural pests, and also museum pests. Within the landscape zone are turf and ornamental pests, wildlife pests, and a wide range of pest weeds.

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APPENDICES:

I. INTRODUCTION

Nez Perce National Historical Park (NEPE) was established as a unit of the national park system on May 15, 1965, by Public Law 89-19. The law specified the park is to "facilitate protection and provide interpretation of sites in the Nez Perce Country of Idaho that have exceptional value in commemorating the history of the Nation." A total of 24 sites were established in 1965 ranging from roadside pullouts to 100 acres in size, with 152 acres in National Park Service management.

Public Law 102-576 of October 30, 1992, allowed sites to be designated in Oregon, Washington, Montana, and Wyoming. It specified that 14 sites in Idaho, Oregon, Washington, and Montana should be included in the park. These sites ranged from pullouts to the 1,250 acre White Bird Battlefield, bringing the total acreage National Park Service management to approximately 2500 acres.

On the basis of provisions in the enabling legislation, some of the purposes of Nez Perce NHP are to:

- facilitate protection and offer interpretation of the Nez Perce sites in Idaho, Oregon, Washington, Montana, and Wyoming that have exceptional value in commemorating the history of the United States

- preserve and protect tangible resources that document the history of the Nez Perce peoples and the significant role of the Nez Perce in North American history.

This IPM plan is congruous with the legislative framework of the park and NPS for ensuring that public and management uses of the park are consistent with the highest standards of resource protection and providing opportunities for public education in resource conservation ethics. This plan will aid managers in the preservation and protection of native plant and animal life as well as natural and cultural resources. The park cannot operate in a vacuum. Cooperative efforts must be established with land managers outside the boundaries of the park in order to fight invasive plant and animal species on an ecosystem basis.

II. LEGAL AUTHORITIES AND REQUIREMENTS

National Park Service (NPS) policy has established IPM as the preferred method for managing pests in parks and monuments. The NEPE IPM program is based on and directed by various policies, laws, regulations, executive orders, and presidential memorandum.

A. Federal Regulations

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) of 1947; amended by P.L. 92-516 (82 Stat. 973) and P.L. 94-140 (89 Stat. 751)
Federal Environmental Pesticide Control Act of 1972 (7 U.S.C. 135 et.seq.)
President Carter's 1979 Executive Order requiring all Federal Agencies to use integrated pest management technology for pest control and reduce the use of toxic pesticides
Executive Order 12088 concerning Pollution Control
Executive Order 11787 concerning Exotic Organisms
Executive Order 11870 concerning Animal Damage Control
Resource Conservation and Recovery Act (40 CFR 165) concerning disposal of pesticides
Migratory Bird Treaty Act
Endangered Species Act
Occupational Health and Safety (OSHA) Hazard Communication Standard (29 CFR 1910.1200)

B. NPS Guidelines and Policy

Guide for Pesticide Use in the National Park Service, WASO (Sept 1985)
Director's Memorandum NSO (485), 1985.

> "My authority to approve pesticide use proposals has been delegated to the Associate Director, Natural Resources, who is provided technical support by the Servicewide IPM Coordinator in the Biological Resources Division. Regional IPM Coordinators will review all pesticide use requests submitted by parks and act on those requests by either denying them, suggesting changes, or recommending to the Servicewide IPM Coordinator that they be approved."

NPS Management Policies (1978, revised in 1991)

> "The Service's use of all pesticides shall be approved by the Director. Application shall be in accordance with applicable laws, Departmental and Service guidelines, and Environmental Protection Agency and Occupational Safety and Health Administration regulations."

Implementation of IPM practices in NPS field areas has been a Servicewide goal since 1979. Information describing the design, application, and evaluation of park IPM programs (and regulations and policies governing them) are found in Chapter 2, Integrated Pest Management, of NPS-77, Natural Resources Management Guidelines (1991). This guideline provides details of the program under the following headings:

- Overview of IPM
- Components of an IPM program
- IPM Program Operations
- Roles and Responsibilities
- Report forms and directions for completing them

Additional guidelines relating to the park's IPM program are found in other chapters of NPS-77:

> Chapter 2: Vegetation Management; Native Animal Management; Freshwater Resources Management; Endangered, Threatened, and Rare Species Management; Exotic Species Management; Hazardous Wast Management; and Public Health and Safety.
>
> Chapter 3: Agricultural Use, Right-of-Way and Easements, and Backcountry Recreation Management.
>
> Chapter 4: Environmental Compliance
>
> Chapter 5: Special Use Permits and Collections.

The National Park Service review and approval process for all pesticides used in a park has been changed as a result of a reorganization in the IPM program. Current review/approval processes must follow the procedures identified in the IPM reengineering memorandum dated March 10, 1997.

C. State Regulations Covering Pesticide Use

The states of Oregon, Idaho, and Montana require anyone applying restricted-use or state-limited-use pesticides to be licensed as a pesticide applicator or be supervised by a person certified as such. These and other rules defining the use of pesticides are listed in:

> Idaho Pesticide Law, Chapter 34, Title 22, Idaho Code
>
> Chapter 10, Pesticides Act, Administrative Rules of Montana
>
> Oregon Revised Statutes, Chapter 634 and Associated Oregon Administrative Rules, Chapter 603, Division 57

III. PARK MANAGEMENT STRATEGIES

A. Objectives

The overall objective of the IPM program at NEPE and BIHO is the protection of human health and welfare, as well as the protection of the natural and cultural resources of the park. With this in mind, native pests will be allowed to function unimpeded except where control is desirable under the following circumstances:

- To prevent the loss of the host or host-dependent species from the ecosystem.

- To conserve threatened, endangered, or unique faunal/floral specimens or communities.

- To preserve, maintain, or restore the historical integrity of cultural resources.

- To conserve and protect fauna/flora in developed zones.

- To manage a human health hazard as defined by the Centers for Disease Control or to protect against a significant threat to public safety.

- To prevent outbreaks of the pest from spreading to forest, trees, other faunal/floral populations/communities outside the park.

In Historic Zones, pest control may be undertaken to prolong the life of historically significant resources present during or representative of the time of commemorated events; however, consideration will first be given to the fact that endemic pest populations may be typical of historic, pesticide-free times. Pest management may be initiated in Historic Zones: to protect the integrity of the historic scene, or to prevent pest outbreaks from spreading to uninfected floral/faunal resources outside the park.

Exotic species are those which occur in a given place as a result of direct or indirect, deliberate or accidental actions by humans.

Exotic plant and animal species already present in a park will be manipulated/eradicated whenever such species threaten the protection or interpretation of resources being preserved in the park by:

- being detrimental to public health
- disrupting faithful presentations of the historic scene
- damaging historic and archeological resources
- threatening perpetuation of natural features, native species, natural ecological communities, or natural ecological processes
- significantly hampering management of adjacent park or non_park lands

All decisions to control exotic species will consider all possible impacts on park resources and will consider available alternative control methods and their probabilities for success. Development plans to control pests or implement pest control activities for any of the above reasons will follow prescribed Servicewide IPM recommendations and guidelines and will include provisions for public review and comment, where necessary. Extreme care will be taken to assure programs to control exotic pests do not ultimately result in significant or unexpected damage to native species, natural ecological communities or processes, historic objects, or public health. A decision to use a pesticide will be made as a last resort after other IPM methods have been implemented, and then, only the least toxic pesticide which will meet control objectives will be used.

B. IPM Process

1. Build consensus

Implementing a successful IPM program involves defining the roles of the people involved in the problem and its site(s). A "site" can be one room, one acre, or any defined area. The cooperation of the involved parties is essential. This can be described as a "Three Ring Circus", where the characters can be referred to as: 1) occupant; 2) pest manager; and 3) decision maker. The occupant can be a park employee or a visitor. The pest manager is the person who takes action to manage the pest or gives suggestions to manage the pest. The decision maker decides if action will take place. This could be a contracting officer, the CDC officer, the superintendent, or even an outside person. Each of these parties will play different roles in the IPM process. Some of these will be safety, identification, cost, policy, monitoring, reputation, and effectiveness. After establishing roles and responsibilities, a communications link between all circles must be established so that the system is linked and works.

2. Identify pests

An important first step in IPM is the accurate identification of suspected pests. Correct identification provides ways for obtaining additional information on pest species. Frequently the presence of an organism is defined as a pest problem. However, the mere presence of an organism does not always constitute a pest problem. Thus an important first step in developing an IPM approach to pest management is the identification of the suspected pest species. Identification will provide avenues to obtain more information about the particular species, determine if there is a pest problem, and, frequently, determine the cause of the problem. By obtaining a thorough understanding of the problem, IPM approaches can reduce the use of pesticides and their associated environmental effects, and can also provide a long-term, cost effective approach to problem resolution.

3. Review NPS policy

All pest management actions, both chemical and nonchemical, will be reviewed by the Park IPM Coordinator before implementation. NPS Management Policies (Chapter 4) lists specific criteria that must be met before exotic or native species may be managed. Because mechanical and chemical control measures have the potential for adverse effects on natural and cultural resources, implementation of management actions will be reviewed against existing policy to ensure correct actions are taken and the resources are protected to the greatest extent.

4. Establish priorities

By establishing priorities, managers can separate pests that are innocuous from those that are disruptive or have high potential to become disruptive. The resulting priority ranking can then be weighed against the ease or feasibility of control, urgency of action, or the cost of delay in action.

5. Establish action thresholds

An action threshold or action level is the size of the pest population at which some management action must be applied to prevent the pest population from reaching an injury level. In this IPM program, the objective of management action is to suppress the pest population below injury levels, rather than attempt to eradicate the pest.

6. Monitor pests and environment

Monitoring is the regular observation of specific factors related to the pest population and is fundamental to successful IPM programs. Monitoring is necessary to determine the status of pest populations and injury action levels. It is needed to choose the time and place of treatments that are most effective and least disruptive to the natural controls operating to suppress the pest organisms, and that are least hazardous to human health and the environment. Monitoring is also important in evaluating pest management strategies. Monitoring is required throughout the IPM program and should include regular sampling of the pest population and its natural enemies, potential pests in the same environment and their natural enemies, management decisions and practices that could affect the pest or potential pest populations, and weather conditions. Non-chemical treatment strategies should

always be implemented as a first step before the use of pesticides. In some instances, an initial combination of non-chemical and chemical strategies is beneficial to knock-down a pest infestation.

7a. Implement non-chemical management

The IPM concept is based on the fact that combined strategies for pest management are more effective in the long run than a single type of treatment. Non-chemical management options that will be considered are habitat modification, modification of human activities, physical or mechanical techniques such as removal of the pest, and biological controls.

7b. Obtain approval and include pesticides in strategy

Chemical treatment involves the use of EPA-registered pesticides. There is an increasing array of chemicals that are being designed or developed to disrupt various behaviors such as mating, feeding, leaf sprout, etc. Most pesticides, by design, are toxic and therefore should not be considered safe. All pesticides used in this park, with the exception of personal insect repellants, will be approved via this plan or through subsequent amendment.

8. Evaluate - continue monitoring

The evaluation process is also a key component to this IPM plan. Evaluation determines the efficacy and environmental effects of treatment actions, and identifies modifications to pest management programs.

9. Keep records (Pesticide Use Logs)

Detailed and accurate record keeping is fundamental to the success of this IPM program. Not only does it provide a historical record of activities, it also provides information which can be used to justify future activities and also satisfy legal requirements pertaining to the application of pesticides.

C. Interpretation and IPM

Education is a cost-effective strategy. Education efforts will be designed to include all audiences that may be concerned about pest management. Through an effective education program, park staff will come to recognize potential pest problems and take action before problems develop. Park staff who are informed about the objective of the program are more likely to support it. Park staff has a responsibility to educate visitors and others concerned with management of national park areas of park IPM practices and the benefits of implementing these approaches to specific pest problems. The public needs to understand the influence of pests on resources, both cultural and natural, and how these influences cross administrative and/or ownership boundaries.

IV. ROLES AND RESPONSIBILITIES

All park operations must support employee and visitor health, safety, and protection of park resources. Pest management activities deal with all these concerns and cross disciplines and all park lines of operation. Many persons, from managers to even residents, at some time may be involved in pest management activities. For an effective program, it will be necessary for the entire staff, as well as many non-NPS persons, to participate as part of the problem solving team. Designated roles and responsibilities for the NEPE and BIHO IPM program are described below.

A. Superintendent

The Superintendent has ultimate responsibility for the IPM program. However, the Superintendent may delegate program implementation and direction to a designated park IPM Coordinator. The Superintendent also:

- should make all reasonable attempts to provide adequate staffing and funds to implement and accomplish the program and to provide for monitoring, exclusion, and control needs.

- must understand the principles and practices of IPM as well as appreciate the broad scope of IPM strategies and tactics and how they relate to park resources and activities.

- should ensure that the park IPM Coordinator participates in all management decisions that may directly or indirectly influence pest management and provide for the proper training of the IPM Coordinator, and all those participating in the IPM process.

- must ensure that the park IPM Coordinator reviews and obtains required reviews and approvals for all pesticide projects performed within the park, including projects performed by non-NPS employees such as cooperators, lessees and contractors.

- must also ensure that all pesticide applicators are supervised by certified pesticide applicators, and encourage and support regular training for all applicators to ensure that they are up to date on new technology and regulations.

- must ensure that certification requirements established by the FIFRA or states are met by park employees applying or supervising pesticide applications in the park.

B. Chief, Resource Management/IPM Coordinator

The responsibilities of the park IPM Coordinator are addressed in *NPS_77 Natural Resource Guidelines* and the IPM reingineering memorandum. The NEPE and BIHO IPM Coordinator:

- is the focal point of all activities directly or indirectly related to pest management, including maintenance, resource management, interpretation, planning and design, etc., and is responsible for coordinating information exchange and continuing education to park staff about IPM techniques.

- will develop and maintain a survey and monitoring program for pests within the park.

- will evaluate all available physical, mechanical, and cultural control options for acceptability and/or feasibility before using chemical pesticides.

- must attend the NPS IPM course and ensure that personnel applying restricted use pesticides in the park are working under the direct supervision of a certified applicator.

- ensures that all reports, requests, and Pesticide Use Logs are accurate, complete, and are submitted in a timely manner.

- maintains labels and MSDS for all pesticides approved for use. Ensures that applicators have the labels and MSDS during pesticide application.

- will keep the Superintendent abreast of all pest management issues and pesticide use.

The Cultural and Natural Resource Management programs will prepare Resource Management Project statements covering significant IPM plans or operations. Where appropriate, proposals should seek to obtain support funding from the Natural Resource Protection Program, Forest Pest Management Program, and other sources.

C. Museum Curator

Pest management duties for the Museum Curator are important to the park IPM program. The Museum Curator will:

- conduct monthly inspections of the museum and curatorial storage areas, for detection and notation of available pest harborage, pest evidence, and any structural defects that could encourage pests. Inspection results will be recorded on Museum Monitoring Reports and floor plans for proper IPM remedy actions.

- maintain a museum cleaning program.

- will forward copies of all Inspection and Monitoring reports to the park IPM Coordinator who will advise the Superintendent of the findings. The Museum Curator and/or IPM Coordinator will use findings from the Inspection and Monitoring Reports to justify Work Orders for structural repairs which will be directed to the Maintenance Division. The IPM Coordinator will maintain a permanent file of work completed. Museum pest treatment strategies will be coordinated between the Museum Curator and the park IPM Coordinator.

D. Maintenance Supervisors

The Maintenance Supervisors will:

- ensure proper storage and safety precautions are maintained for all pesticides and/or application within the park.

- assure applicators are properly licensed in accordance with state and local ordinances or are supervised by a licenced applicator.

- ensure that proper training and safety procedures are followed for all IPM processes.

- utilize proper control techniques/strategies and recommend new procedures as appropriate.

- train maintenance staff to be alert to conditions and signs of pest and pest damage and, if found, will report findings to park IPM Coordinator.

- assure good sanitation procedures are carried out to reduce factors encouraging pests and quickly report any damage or infestations.

- punctually schedule repairs to structures, utilities, or vegetation that may support pest infestations.

E. Pesticide Applicators

Pesticide applicators will:

- perform duties in accordance with the individual state laws.

- provide careful instruction and oversight when using others in performing applications.

- maintain proper application records and documentation.

- keep training and skill current, as well as maintain certification by applicable states.

F. Park Residents

Park residents have the responsibility to maintain their quarters and surrounding areas in a clean and orderly manner so as not to attract or provide harborage for pests. Residents must promptly report maintenance needs which would harbor pests to the park IPM Coordinator and the Lead Maintenance Employee. Residents are not allowed to use pesticides (insecticides, rodenticides, herbicides, etc.) which have not been previously approved through the park IPM Coordinator.

G. Administrative Officer

It is the responsibility of the Administrative Officer to ensure that all purchase orders for pesticides have been approved by the park IPM Coordinator. No pesticide can be purchased prior to that pesticide being approved under this plan, or by the Columbia Cascades Support Office or the Washington Office IPM Coordinator.

F. Columbia Cascades Support Office IPM Coordinator

The CCSO IPM Coordinator is a key player in the park IPM program and serves as a liaison between the park and the Servicewide IPM Coordinator. The CCSO IPM Coordinator provides IPM training and information to develop management strategies, keeps the park apprised of changes in policy or pest management technology, reviews proposed park IPM plan and pesticide application programs or projects, and confirms proposed use of pesticides that are essential within the park IPM strategy.

V. SAFETY

A. Certification

The following table provides a listing of the current training and certification of park employees within the park. No employee will work with pesticides without proper protective equipment. No pesticides will be applied by park employees without proper training or supervision by a certified pesticide applicator.

Employee Name	Training	Certified Applicator
Ben Attao	NPS IPM Training; Idaho Pesticide Applicator; Worker Protection Instructor	Idaho
Dennis Groseclose	Idaho Pesticide Applicator; Worker Protection Instructor	Idaho
Jesse Kipp	NPS IPM Training; Idaho Pesticide Applicator	Idaho
Chief of Resource Management	NPS IPM Training	

B. Pesticide Information

Pesticide labels contain directions to protect workers and reduce exposure to nonapplicators. Violation of those directions is a violation of FIFRA. Existing labels on incoming chemical containers will not be removed or defaced and, under OSHA's Hazard Communication Standard (29 CFR 1910.1200), workers will be provided with training, protective equipment, and information (Material Safety Data Sheets, MSDS) about the hazardous substances they may handle. Information will be made available to the public by posting treated areas. Public information will include: pesticides used, areas treated, and safe entry times. Listing and records will be kept for all pesticides used or stored in the park. Copies of the labels and MSDS sheets will be stored with the pesticides and in the office of the park IPM Coordinator.

C. Pesticide Storage

Pesticide storage facilities will be locked, fireproof, and ventilated, and proper warning signs will be posted. Pesticides will be stored separately from all other substances, and the directions provided on the label or labeling will be followed. In addition, each type of pesticide will be stored on separate shelves. Insecticides and herbicides, for example, will be stored in separate rooms because of the potential for explosive or other violent chemical reactions when these types of pesticides are mixed. Storing pesticides with cleaning fluids, paints, solvents, or other chemical substances unnecessarily increases the opportunities for accidents, fires, etc. Structures used for the storage of pesticides will be posted, and copies of labels, MSDS, and inventories will be kept in the storage facility. Pesticides will not be stored in or moved into unapproved or unmarked containers. Local fire departments will be made aware of the types and locations of pesticides, at least annually. It is recommended an annual fire inspection be conducted of pesticide storage facilities.

Safe storage of pesticides in personal residences in the park is critical for the protection of residents, their children, and domestic animals. Residents will be informed of the following recommended guidelines for storing pesticides

in the home.

- Do not purchase pesticides for use in or around your residence, garden, or yard which have not been approved through the park IPM Coordinator.
- Keep all pesticides locked up, where children cannot find them.
- Do not store pesticides in the same cupboards with food, animal feed, seed, or water.
- Do not store pesticides beneath the kitchen sink where they are in reach of children.
- Store pesticides in dry, cool, well_ventilated places, away from sunlight and at temperatures above freezing.
- Mark all entrances to pesticide storage areas with a sign: "Pesticides Stored Here _ Keep Out".
- Store and keep all pesticides ONLY in original and originally_labeled containers.
- Clean up spilled and leaking pesticides immediately.
- Indelibly write the date of purchase on pesticide containers.
- Many pesticides are flammable. Take adequate precautions against potential fire hazards.
- Keep all safety data and other information that comes with pesticides and forward to the park IPM Coordinator a copy of the label.
- Do not mix storage of herbicides and insecticides; store on separate, labeled shelves.
- Keep the Poison Center phone number handy: 800_541-5624 (Northern Idaho)
  800-525-5042 (Montana)
  800-452-7165 (Oregon)

D. Disposal

All pesticides, rinsates, and pesticide containers will be disposed of as per pesticide label directions and regulations established by EPA (40 CFR 116_117, 165, 170_172), and the Resource Conservation and Recovery Act. (40 CFR 261.30_33).

There are several approaches which will limit the amount of excess pesticide to be discarded. NPS policy limits the quantity of pesticide which can be purchased. The pesticide label or labeling also contains information about disposal of pesticides and pesticide containers. Mixing only sufficient pesticide to do the immediate job will eliminate surpluses. However, if small quantities of mixed pesticides remain, they and any rinsate from the container or spray equipment may be applied to the treated area according to the label instructions. At the completion of any application where a spayer has been used, the sprayer will be triple rinsed and the rinsate will be applied according to the label instructions.

If pesticides cannot be disposed of in the manner described above, they may be surplused, given to another agency, or disposed of according to federal and state laws and regulations. Donation of surplus chemicals will be documented and records kept for three years.

E. Training

The Park IPM Coordinator will complete the NPS IPM training course or an equivalent training. In addition, the IPM Coordinator may maintain certification as a pesticide applicator.

All employees applying pesticides or other chemical pest controls will receive appropriate training to be and remain certified by the state(s) in which they work in one or more categories as a Pesticide Applicator, or be directly supervised by a Certified Pesticide Applicator. The states of Washington, Oregon, Idaho, and Montana have reciprocal agreements on pesticide applicator certification and therefore eliminate the need for multiple certification.

Employees performing visual inspections/monitoring will receive at least eight hours of documented IPM training, including methods of conducting structural inspections.

Personnel performing rodent control work will receive at least 16 documented hours of instruction, including monitoring and inspection techniques, disease prevention, techniques for rodent control, sanitation, safety, and familiarity with appropriate pesticides.

Employees required to manage stinging insects (honey bees, wasps, yellow jackets, hornets) will receive at least four hours of training, including safe equipment use, insect and nest removal methods, bystanders management, and emergency first aid procedures. Employees who must destroy colonies or nests of stinging insects will wear protective clothing which consists of a tight bee suit, hat, bee veil, and gloves. All records of IPM training will be maintained by the park IPM Coordinator. It will be the responsibility of each certified applicator to maintain certification, lists for certification, and reimbursible.

F. Notification

Some pesticide labels contain a re-entry interval precaution. This statement tells how much time must pass before people can reenter a treated area without appropriate protective clothing and/or equipment. Re-entry intervals are set by both the EPA and some states. Reentry intervals set by states are not always listed on the label and therefore is the responsibility of the park staff to determine if one has been set. If re-entry limitations have been established for applied pesticides, the areas of treatment will be posted on all sides and entryways stating the type of pesticide applied, date of treatment, and date of safe re-entry. If no re-entry statement has been set, then all unprotected persons must wait at least until sprays have dried or dusts have settled before re-entering without protective clothing. This is the minimum legal re-entry interval.

A list of park employees who are sensitive to pests or pesticides will be maintained in the park IPM Coordinators office and in pesticide storage areas. Prior to application of any pesticides, these individuals will be notified for their safety.

A list of sheriff, hospitals, fire suppression, and EMS providers is provided in Appendix C.

G. Spills

The key to preventing pesticide spills is proper equipment maintenance and a knowledge of safe handling and application techniques. In the event of a spill, the steps of contain, control, and clean will be applied in as safe a manner as possible.

1. Control the spill

Without exposing anyone unnecessarily to chemicals, immediate steps need to be taken to stop the flow of the material being spilled. Proper protective equipment must be used to control leaks, or extricate injured personnel from accident scenes.

Isolate the spill area and keep people at a distance of at least 30 feet. In some instances, evacuation upwind from the spill may be warranted. Oversight must be maintained at the spill site until the chemical is cleaned up, so park staff will be on site until relieved.

In large spills, it may be necessary to get help. In such a situation, contact the Idaho Emergency Response Commission at (800) 632-8000, in Montana contact the Disaster and Emergency Services through the 911 network, or in Oregon contact the Pesticide Analytical and Response Center at (503) 731-4025. These are 24 hour services. Another resource for emergency information is the Chemical Transportation Emergency Center (CHEMTREC) in Washington, DC, at (800) 424-9300. Have the product label available for technical information.

In some cases it may be necessary to notify local police, fire department, hospitals, and/or public health officials.

2. Contain the spill

It is imperative that the spill be contained in as small of an area as possible. Every practical step should be taken to keep the spill from spreading by using hand tools, absorbent materials, and other resources available.

Do not allow spilled materials to enter any water body, including sewer, even if the spill is insignificant. If this happens, the state or regional Health Department must be contacted, so authorities can notify downstream users of

any potential hazards.

Sand, vermiculite, clay, sawdust, or absorbent pads spread over entire spill areas can absorb liquid spills. Due to fire hazards, do not use sawdust or sweeping compounds on spill materials that are strong oxidizers. These materials are available in the parks two primary hazard waste accumulation areas (Spalding and Big Hole Maintenance areas) and at the parks secondary hazard waste accumulation areas (White Bird, East Kamiah, and Bear Paw storage sheds).

Dry chemical spills can be contained by misting the area lightly with water or covering with plastic. Care must be taken when disposing of all material, even clothing, used in spill management, as noted in the clean up section below. These materials can also be obtained in the park's hazard waster accumulation areas.

3. Clean up the spill

Absorbent material should be spread over the entire spill. Additional absorbent should be added until the spill is soaked up. If possible, dry materials can be cleaned up and reused, unless they are contaminated with soil and/or debris. If the latter, they should be placed in a heavy-duty plastic bag for disposal. These materials are stored in the park's hazard waste accumulation areas.

Decontaminate the area by cleaning with a mixture of full strength household bleach and hydrated lime. This mixture is worked into the spill area with a coarse broom. The mixture is then cleaned up by adding absorbent material, such as sand, and soaked up, scooped up and placed in heavy-duty plastic bags for disposal. Repeat this process several time, ensuring the area has been thoroughly decontaminated. Do not hose down the area with water. This procedure is to be used for all spills.

If soils are contaminated, the most effective way to remove a pesticide is to remove the top 2 to 3 inches of soil, cover the area with a layer of lime, and cover that layer with fresh topsoil. The contaminated soil must be disposed of in an approved hazardous waste disposal facility.

Equipment cleanup is as important as cleaning the spill. This must be done while wearing proper protective equipment. Clean all equipment with chlorine-dish soap solution. Porous equipment (leather, brooms, etc) and/or clothing that is badly contaminated cannot be decontaminated effectively and therefore should be placed in heavy duty plastic bags and disposed of properly.

If spill material is useable, it may be applied at or below the labeled rate. If this is not an option, the material must be disposed of in accordance with state hazardous waste disposal regulations.

All spills will be documented as to date, size, corrective actions taken, and any agencies contacted for assistance or regulatory compliance.

Spill kits will be available in the Spalding Maintenance shed, East Kamiah shed, and in the Big Hole Maintenance storage. Because of the disjointed nature of NEPE, spill kits will be carried in the park vehicle when working at White Bird Battlefield, Canoe Camp, or Bear Paw Battlefield.

Mixing locations will be limited to the maintenance areas/sheds of Spalding, East Kamiah, and Big Hole Battlefield. At Canoe Camp and Bear Paw Battlefield, mixing will be confined to the parking lot areas. White Bird Battlefield has no parking lot and therefore the designated mixing place will be at the White Bird Village site.

H. Other Safety Concerns

Employees will take safety precautions in using ladders and tools, and be informed about other specific work and pest hazards concerned with IPM duties. These may include:

- Workers on ladders will be warned about the hazards of encountering stinging insects.
- Visitors will be kept away from stinging insect control operations, and personal protective clothing will be worn by personnel.

- Personnel who must handle live poisonous snakes will receive proper training, wear personal protective equipment, and use proper equipment. Native poisonous snakes will be released within the park.
- A hazard tree monitoring program will be utilized to reduce potential staff/visitor injury.

VI. DOCUMENTATION

A. Monitoring

The first step in managing pest problems is to identify the problem. Inspection enables discovery of pests or habitats supporting them. Inspections will precede any park pest control actions to identify pests, pest locations, treatments needed, and programs to monitor success of actions.

Monitoring is the regular observation of specific factors related to the pest population and habitat and is fundamental to a successful IPM program. It is needed to choose the time and place of treatments that are the most effective and least disruptive to the natural controls operating to suppress the pest organisms, and that are the least hazardous to human health and the environment. Monitoring is also important in evaluating pest management strategies. The monitoring program of the park will address the following seven areas:

1. The purpose of the monitoring.

2. Target or potentially affected nontarget populations sampled.

3. Frequency of monitoring.

4. Appropriate sampling locations and number of sites to monitor.

5. Monitoring procedure.

6. Accuracy and detail of records for future decision making.

7. How monitoring will be used to evaluate treatments for effects on target and nontarget organisms.

Additional guidelines for inspection and monitoring are found in NPS_77, Chapter 2, page 226.

Completed inspection and monitoring data will be maintained in permanent files by the IPM Coordinator. Any structural repairs needed will be noted and forwarded to the Maintenance Division for repair.

B. Pesticide Use Proposals/Approvals

This IPM plan covers pests that are common to NEPE and BIHO. Any pesticide use prescribed in this plan will be approved for four years or until research recommends other methods, whichever is less. At the end of four years, this plan will be reviewed by park staff, supplemented if appropriate and resubmitted to the CCSO IPM Coordinator for concurrence and approved by the park superintendent. Pesticides not covered by this plan require individual annual approval through the IPM software.

C. Pesticide Use Logs

In addition to having pesticide use approved under this plan before it is applied on lands or facilities owned, managed, or regulated by the NPS, the park is required to maintain records for each pesticide used during the year. At the end of each calendar year, an annual report concerning the use of each pesticide is required. The park IPM Coordinator, who maintains the pesticide management software (PUPS), will compile the Pesticide Use Logs into the electronic databases. This information is then submitted the CCSO IPM Coordinator, who checks the Pesticide Use Log for accuracy, compiles the individual park Pesticide Use Logs, and submits them to the Servicewide IPM Coordinator.

D. Labels, Material Safety Data Sheets

Pesticide labels carry directions to protect workers and reduce exposure to nonapplicators. Violations of those directions is a violation of FIFRA. Labels on chemical containers will not be removed or defaced. Under OSHA's Hazard Communication Standard (29 CFR 1910.1200) workers will be provided with training, protective equipment, and information (MSDS sheets) about the hazardous substances they may handle. Information will be made available to the public by posting treated areas with information on pesticides used, area treated and safe entry times. Records will be kept for all pesticides used or stored in the park. Copies of labels and MSDS sheets will be stored with the pesticides and in the office of the park IPM Coordinator and should also be in a notebook with the applicator and with dispatch.

E. Pest Management Actions Taken

The National Park Service, in 1996, instituted the use of a nationwide IPM software program which facilitates record keeping and tracking of pest management actions. The database structure replaces the old Form 10-21A pesticide approval application, while providing a format for tracking pest management actions taken, including pesticide applications. Figure 1 provides an example of the database and the capabilities for recording management proposals and actions. At the end of each year, the previous years applications must be entered into the software.

Figure 1. National Park Service IPM Software example.

Last Update: 04/11/96 NATIONAL PARK SERVICE
PESTICIDE USE PROPOSAL
Proposal # : NEPE_96_001 Cluster: CCC State: ID
RMP Number : NEPE_I_172.003
Target Pest 1: RUSSIAN THISTLE (TUMBLE)
Target Pest 2: SPOTTED KNAPWEED (SPOKNA)
Target Pest 3: YELLOW STAR THISTLE (YESTTH)

Pesticide Type: Herbicide (H) Herbicide Type: BOTH
Product: TORDON 22K
EPA number : 62719_6 Manufacturer: DOWELANCO
Formulation: (SC) Purpose: EXOTIC PLANT CONTROL
1st active : PICLORAM (PICLOR)
Method of application(s): Backpack (BP)
Proposed Application site 1: EXOTICS Start mo. : 2
Proposed Application site 2: End mo. : 10
Number of acres to treat: 4.0000
Number of sq. feet to treat: 0
Application to a cultural zone _____? Y
Application to a special use zone _____? IPM contact: DAN FOSTER
Application to a developed zone _____? Y Phone: (208) 843_2261
Application to a natural zone _____? Y
Application to a body of water _____? N Coord. With: BOB CHENOWETH
Is the product EPA "Restricted Use" ___? Y Phone: (208) 843_2261
Potential impact on T&E species _____? Y
Will there be multiple applications ___? Y
Application approved last year _____? Y
Is there an established threshold _____? Met
Monitoring pest population trends _____? Y
Have non_chemical methods been tried __? Y
Application to control exotic species _? Y
Year of last approved IPM plan _____?

_____Unit of measure: lbs (PICLOR) applied: 0.00

F. Purchasing/DI-1's

The policy of the NPS regarding the purchase of pesticides is very specific. NPS personnel are permitted to purchase the amount of pesticide authorized for use during the year of approval only. An exception to this policy is allowed if the smallest amount available for purchase is larger than the amount necessary for the project. For example, if one quart of pesticide is needed but it can only be purchased in two quart containers, then the larger quantity may be purchased.

Requisition forms (DI-1's) or IMPAC cards should not be used for pesticide purchase without an attached form approved Pesticide Use Proposal that has been reviewed and approved under this IPM plan or an amendment. If an approved pesticide is unavailable for purchase, any substitutions with different active ingredients will require approval through the same process. The park IPM Coordinator is responsible for informing the purchasing/procurement office of the procedures.

There are a variety of reasons for limiting the amount of pesticide that a park may purchase at one time. Many pesticides have a very short shelf life, are photosensitive, or may degrade on exposure to air; a pesticides's registration may be changed by EPA; a more suitable product or technique may become available; or new information about the environmental impacts may become available. If the pesticide becomes unusable for any of these reasons, the park will be faced with disposing of a pesticide which may have to be treated as hazardous to toxic material. The cost of disposing of these materials often equals or exceeds the purchase price of the pesticide. In addition, pesticides must be stored under specific conditions. For large quantities of pesticides, this may require building special storage facilities. There is also the danger that pesticides will catch fire or be involved in fires, potentially creating hazardous or toxic fumes and runoff which require special fire fighting techniques, or may require evacuation of personnel. Therefore, even though a pesticide may be approved for use during the next year, it is recommended that only the quantity necessary for each application be purchased.

G. IPM policy/practice statement/requirements

There are several situations at NEPE/BIHO which would allow for the introduction or proliferation of pests within the park. Any visitor entering park grounds may be a transporter of pests. At many NEPE sites transportation networks, highway and railroad, may serve as sources for pest introduction. Streams and other water sources may also serve as transport mechanism for pest infestations.

Throughout the year, various events are either hosted or occur on NEPE and BIHO managed property which may affect pest management. Example events are Cultural Days at the Spalding Site, special ceremonies to commemorate battles or cultural events, and social gatherings. At many of these events food is often brought onto park lands which can attract pests such as yellow jackets and bees. Garbage cans will be provided in appropriate locations for waste deposit.

For many of these events, horses are brought into the park for cultural displays, parades, or ceremonies. In these situations, it is a strong possibility that manure deposited on the ground contains seeds of species that are undesirable in the park. For these events, it will be required that owners/operators either quarantine their animals for a minimum of three days, while feeding only weed free seed, or provide guarantees that all deficants will be promptly cleaned up before leaving the site.

H. Cooperative Agreements

NEPE and BIHO participates in several cooperative efforts with other agencies/individuals in the management or eradication of pests. A cooperative agreement between BIHO and the Beaverhead National Forest (BNF) exists for cooperation in weed control. Under this agreement, BIHO will provide limited manpower and pesticides and BNF provides the equipment and a certified pesticide applicator to conduct the work. This effort has been in place for several years and a copy of the agreement is in the appendix.

No other formal agreement is in place, however, the park Integrated Resource Program Manager/IPM Coordinator participates in cooperative weed control efforts with the Salmon River Weed Management Council and the

Clearwater River Weed Management Council.

VII. PARK PESTS BY ZONE

Major pest issues at NEPE and BIHO relate to the needs for preserving cultural and natural resources to the maximum extent possible, while also providing for the health, safety, and comfort of visitors and staff. The following list of pest concerns at NEPE and BIHO was gathered as background for the current IPM Plan.

A. Structural Pests

1. Interior (e.g., Visitor Centers, residential, concessions, maintenance shop, storage, etc.)

Mice (Peromyscus, Mus species) are the most common rodent pests that enter residences, NPS warehouses, and other structures. Hantavirus has been documented in rodents at Big Hole. Park staff members need to maintain sanitary conditions and guard against possible diseases that are known to exist in rodent populations.

Numerous species of ants occur in NEPE and BIHO, but some become common pests in visitor centers, buildings, and houses.

Bees, wasps, hornets, and yellow jackets become common problems around buildings each summer and fall season, particularly at the Spalding Site, and worsen until the arrival of cold winter weather. Yellow jacket problems are greatest in and around buildings.

Black widow spiders have been noted near residences and in buildings.

Accidental pests such as earwigs and crickets are occasionally found in park buildings.

Flies commonly frequent park facilities.

Cockroaches and silverfish have been found in the visitor centers and other buildings. These insects are regarded as a serious health threat and silverfish can affect historical collections. Other insects such as carpenter ants, carpenter bees, and termites may also pose serious resource threats.

2. Exterior (e.g., walls, posts, siding, etc.)

Some park residents keep pet animals and may experience flea problems. Flea problems can occur in residences, offices, or other buildings as a result of wild animals utilizing open spaces in or under them.

Bees, wasps, hornets, and yellow jackets are commonly encountered each summer and fall season. Yellow jacket concentrations are greatest on the Spalding site around buildings and in the picnic area.

Numerous species of ants occur in NEPE and BIHO.

Black widow and other spider species are common residents, especially in covered areas near buildings.

Northern flickers have caused damage to structures at several sites in Idaho.

Other insects such as carpenter ants, carpenter bees, and termites may also pose serious resource threats.

3. Museums

Pests that are commonly found in any building may become pests in museums. Some pests repeatedly threaten museum collections. These are grouped into categories such as fabric, wood, stored products, moisture, and general pests. Some found at NEPE and BIHO are carpet beetles, moths, and cigarette beetles.

B. Landscape Pests

1. Turf and Ornamental Plants

The most common weed in the turf lawn areas of the park is the common dandelion. There are also a wide variety of pest plants that continually grow in cracks in the sidewalks and roads.

2. Wildlife Pests

Vertebrate pests such as skunks, ringtail cats, badgers, porcupines, and other larger mammals sometimes enter crawlspaces and other structures, where they cause odors, nuisances, damage, and introduce fleas.

Other wildlife such as deer may enter visitor_use areas and beg food from visitors or scatter garbage and become nuisance pests.

Beaver may cause damage to and may alter cultural and historic scenes.

Mosquitos create unpleasant experiences to visitors and staff, particularly at Big Hole Battlefield during the summer and fall seasons.

Moles, pocket gophers, and voles cause considerable damage to turf grass areas and earthworks.

Ground squirrels at Big Hole and Bear Paw Battlefields have the potential to carry plague, although this has not been documented at any park sites.

Rattlesnakes are frequently found each year near buildings and visitor_use areas.

Ticks may be found in most outdoor areas of the park, but especially in shrub or tall grasslands. Ticks may transmit several diseases and pose serious health threats to those affected.

3. Noxious weeds/exotic species

The most malignant and aggressive pest problem at NEPE and BIHO comes from the invasion of park and surrounding lands by exotic vegetation and weeds. Many exotic plants which out_compete native vegetation occur on NEPE and BIHO lands were intentionally or accidentally introduced. A brief listing includes, but is not limited to: yellow starthistle, poison hemlock, field bindweed, Canada thistle, bull thistle, scotch thistle, spotted knapweed, chicory, common mullein, Russian olive, tamarix, black locust, sumac, white poplar, cheatgrass, medusa head, Russian knapweed, teasel, and moss species.

Appendices:

Appendix A. Pest Information

The following section is intended for reference on the most common pests within the park.

The information is listed alphebetically by species or grouping. The format for each listing is:

Common Name - listing of the common name(s) of the pest or grouping of pests.
Identification and Biology - brief description for identification and biology.
Occurrence in the park- where the pest(s) may occur within the park.
Potential damage and health concerns - description of major damage and health concerns.
Monitoring and Thresholds - what monitoring is done and when to begin treatment.
Non-chemical Management - non-chemical management alternatives.
Chemical Management - chemical management alternatives.
References - where the information was obtained.

This section will serve as the operational reference for all pest management actions.

It is here noted that this does not comprise an all inclusive list of the pests that may occur within the park. This is an attempt to provide managers with information that will be useful in the management of those pests that have been identified as being present or potentially present within the park. Some of the species may not occur, but the park lies within their historic or present range. No attempt is here made to give histories of occurrence or damage, but this document is meant to be a beginning point of reference for managers in dealing with IPM problems at NEPE.

Because of the dispersed nature of the park and the limited staff, active monitoring procedures for all pests listed herein have not been established. When pests are identified, monitoring procedures will be set up with assignments made for their completion being made to those who are in the best position to carry them out. This will be coordinated by the IPM Coordinator, who will also provide proper training in the established protocols.

The chemicals listed in each section under **Approved Chemical Alternatives at NEPE** are those for which this plan provides approval. All other chemicals must be submitted on an individual basis through the IPM approval process.

ACCIDENTAL PESTS

Common Name

There are many common species of wildlife which are normally found in the park environs that occasionally enter park buildings. Some of these will scavenge food and find harborage, but most will die from starvation or dehydration. This group of pests contains a wide variety of insects, arachnids, small mammals, and occasionally birds, amphibians, and reptiles.

Identification and Biology

Some accidental pests only enter buildings when outside environmental conditions become unbearable. Some are attracted to created conditions such as lights or water and accidentally enter buildings. Most of these will not survive for more than a few days under indoor conditions. There are many reasons for this, but the lack of ability to control body moisture and regulate water loss is of primary importance.

Many native pests are distributed across the United States and some of these are potential health risks for residents and/or can cause structural damage.

Occurrence in the park

Accidental pests are usually found outdoors, but will occasionally enter park buildings and become pests. Historically and currently, these are found in all park buildings and under a variety of circumstances. Ants, bees, wasps, spiders, mice, and poisonous snakes are described in other sections.

Potential damage and health concerns

A few accidental pests are health and safety concerns as they are carriers of diseases, sting or bite, damage fabrics, contaminate foods, present an undesirable presence, attract other pests, or create unfounded fears on the part of residents or office workers.

Monitoring and Thresholds

Actions for control of accidental pests will not begin with pesticide treatment. Control should begin with inspections by the IPM Coordinator and maintenance staff to determine entry points/sources, species, and size of infestations. Once the locations and reasons for entry are determined, appropriate corrective actions will usually alleviate the problem.

A program of regular monitoring for presence of accidental pests may need to be established with sticky traps or other means to determine size and location of infestations. Because these are accidental, the threshold for action would be on an as needed basis, based upon tolerance levels of building occupants. Each trap should be numbered and placed against walls, near doorways or in areas where pests will encounter them. Traps must be checked on a regular basis with findings recorded as to species, number, life stage, and a time interval of monitoring. Floor plan drawings will also provide valuable information as to areas of pest activity.

Action Thresholds for accidental pests are subjective and depend on several factors, including potential damage and health concerns, numbers of pests entering a building, and tolerance levels of the occupants or office workers. The presence of accidental pests in a structure is an indication that physical barriers have broken down and inspection for corrective actions is important. Controlling actions will vary according to the individual pest.

Non-chemical Management

Historically, treatment for these pests has rested with maintenance staff, but identification of problems is the responsibility of all park employees and residents. Actions have primarily been limited to efforts of cleanliness and exclusion such as cleaning up work areas and ensuring that doors and windows are closed and have proper screens

and seals in place.

Start with thorough inspection of the interior and exterior of structures to determine points of entry. Once these are located corrective measure can be taken to reduce occurrence of pests indoors. These treatments may be as simple as repairs to window screens, calking, installation of door sweeps, use of heavy bodied paints to seal cracks, or simply requiring doors to be closed.

Placement of sticky traps along walls may act as a minor control measure. Proper cleaning and sanitation for areas is a constant necessity. Remove clutter which provides insect harborage. Repair water leaks.

Many accidental pests will only require corrective actions on a seasonal basis. When the season changes, the problems often disappear. It must be remembered, if the problem is not corrected, it will reappear again. When exclusion is cared for, the infestations will most often disappear.

Each park employee is responsible for proper sanitation in their work area and especially in areas where food is prepared, consumed, and/or stored. The Maintenance Division is reaponsible for the repair of structures or facilities which may provide harborage or entry.

Chemical management

Good exclusion and sanitation should always be practiced and affirmed prior to use of any pesticide.

After proper sealing, pesticides should be applied to cracks, holes, or other small openings where pests are persistent problems. Spray or dust applications of boric acid, Drione, silica aerogel, resmethrin are labeled for such uses. Some residual pesticides (resmethrin, diazinon, malathion) are labeled for band_application to outside foundation walls, flower and/or ornamental plant beds, unfinished basements, and crawl spaces.

Silica aerogel bands can be placed across door sweeps, in window frame joints and other cracks into a structure, and in other insect harborage areas to effectively repel invertebrate pests for a number of weeks. Once the pyrethrum evaporates, the fine silica residue (sand) remains on surfaces and will continue pesticidal action.

Fog and spray treatments may be used in rooms to control pests. These treatments do not penetrate hidden surfaces well and effectively treat the underlying causes of infestation (i.e. poor sanitation or exclusion).

Approved Chemical Alternatives at NEPE:

Allethrin (with piperonyl butoxide) aerosol space treatments for flying insects;
Boric acid baits (liquid and solid) for ants, roaches, silverfish, and other indoor pests;
Boric acid dusts for cracks and crevices;
Carbaryl dust for outside pests (carpenter ants, fleas in rodent burrows);
Diatomaceous earth dusts;
Diatomaceous earth dusts with pyrethrins;
Diazinon for outdoor pests;
Fenoxycarb insect growth regulator for ants, fleas, roaches;
Methoprene insect growth regulator for fleas, ants;
Pyrethrum (synergized with piperonyl butoxide) for moth proofing; contact sprays;
Resmethrin aerosols for space treatments, honey bees; outside applications;
Silica aerogel for dusting cracks and crevices and along pathways used by pests;
Silica gel with pyrenone for cracks and crevices;
Wasp freeze chemicals (without CFC's) for wasps.

Other chemical alternatives that must have prior approval include:

Benzyldiethyl methyl ammonium saccharide gustatory inhibitor for woodpeckers, rodents, or animals that gnaw on structures/wires;

Hydramethylnon baits for ants, roaches, and crickets;
Malathion for outdoor pests;
Potassium salts of fatty acids (soaps) for insects on plants.

Resources

Materials Available

Materials available include common sense items such as doors, window screens, and basic sanitation procedures.

Technical Experts

Since these instances are of such an occasional manner, no technical experts are listed. The best place to start would be to consult with the County Extension Agent for the area.

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ANTS

Common Name

Ants are among the most successful insects. Experts estimate that there could be 20,000 or more species of ants in the world. They have evolved to fill a variety of different ecological niches as predators, herbivores, leaf-cutters, seed-harvesters, aphid- tenders, and fungus-growers. They are found in deserts and rainforests, mountains and valleys, from the Arctic Circle to the tip of South America. They are interesting organisms that should be studied to better understand their unique behaviors and their roles in the earth's ecosystems.

They can also be pests, however. Fire ants and others may sting or bite people and animals. Pharaoh ants get into wounds and dressings in hospitals. House-infesting ants can become pests by their presence in kitchens and living areas. Carpenter ants tunnel into structural wood. Mound-building ants mar the appearance of lawns and landscaped areas. Sometimes ants must be managed to suppress a pest problem.

Identification and Biology

Only a comparatively small proportion of ant species are damaging and require control. For National Park Service personnel, the ants most often of concern will be species in three groups: fire ants, carpenter ants, and house-infesting nuisance ants. The first two are discussed in separate Integrated Pest Management modules. This module addresses the third group, house-infesting ants--those ants that most commonly invade structures looking for food, water, or nesting sites.

A detailed description of every pest ant is beyond the scope of this module. Well over a dozen are considered common pests of structures, and many others are occasional pests. Detailed information on identification, biology, and management of specific pest ants can be obtained from the University of Idaho Cooperative Extension Service.

<u>The Ant Colony and Life Cycle</u>

Ants belong to the insect order Hymenoptera, which also includes the wasps and bees. Ants are distinguished from many of their nearest relatives by two characteristics: a narrow "waist" (the slender free-moving portion of the abdomen called a pedicel) and elbowed antennae.

Ants also differ from most other insects in that they are social, similar to termites and certain bees and wasps. This means that ants live in large cooperative groups called colonies. Two or more generations overlap in the colony; adults take care of the young and are divided into castes, specialized groups that take care of certain tasks. Ants have reproductive castes, the queens and males, and nonreproductive castes, the workers.

A queen is generally the largest individual in the colony. She has wings until after her mating flight, when she removes them. The primary function of the queen is reproduction, but after establishing a new nest she may also care for and feed the first brood of workers. Once she has produced her first brood, she becomes an "egg-laying machine," cleaned and fed by her offspring. She may live for many years until replaced by a daughter queen. Some ant species have more than one queen in the nest.

Male ants are generally winged and usually keep their wings until death. Apparently, the male ant's only function is to mate with the queen. Once he does, he dies, generally within two weeks. Males are produced in old, mature colonies.

The workers are sterile, wingless females who build and repair the nest, care for the brood, defend the nest, and feed both immature and adult ants, including the queen. There may be workers and soldiers of different sizes that specialize in certain tasks.

Species	Worker Size	Color	Thorax Shape	No. of Nodes	Other id Characters	Treatment	Bait
Pavement Ant	3/16"	dark brown	uneven	2	grooves on head + thorax; stinger at tip of abdomen	barrier - good; nest - excellent	sweet
Thief Ant	1/32"	yellow	uneven	2	stinger at tip of abdomen	barrier - poor	sweet
Crazy Ant	1/8"	dark brown	uneven	1	very long 1st antennal segment 2X as long as head	barrier - good; nest - excellent	sweet or protein
Field Ant	3/8"	brown to very dk brown	uneven	1	none	barrier - excellent	sweet
Pharaoh Ant	1/16"	yellow w/ red abdomen	uneven	2	none	barrier - poor	sweet or protein
Argentine Ant	1/8"	brown or lt brown	uneven	1	sparse body hair; no hair on thorax	barrier - poor	sweet

Table 1. Key features used to identify major pest species of ants.

Ants develop through a complete life cycle of egg, larva, pupa, and adult. The egg is tiny, almost microscopic in size. The larva is legless and grub-like, very soft and whitish in color. It is also helpless and depends totally on workers for food and care. The pupa looks somewhat like the adult but is soft, unpigmented, and cannot move around. Some are enclosed in a cocoon, some are not. A newly-emerged adult requires several days for its body to harden and darken.

New Colony Formation

Once a colony of ants matures, it can establish new colonies through various methods, depending on the species. The two most common are budding and swarming. The appropriate management strategy depends on how a colony spreads, so it is essential to correctly identify the ant species before deciding how to manage it.

Budding is the breakaway of a group of ants from a mature colony to form a new colony. The group usually consists of one or more queens and some workers carrying larvae. Budding is common with species of ants that have multiple queens, such as Pharaoh ants and Argentine ants. Residual insecticides should not be used for ants that undergo budding because they can stimulate this process.

Most ants establish new colonies through swarming. Every now and then, particularly in spring or early summer, mature ant colonies generate large numbers of winged forms. These are the young queens and males, going off to mate. An inseminated queen then rids herself of her wings and attempts to start a new nest in a cavity, under a stone or a piece of bark, or by excavating a hole in the ground. She rears her first brood alone, feeding them with salivary secretions and infertile eggs. If successful, the first brood opens up the nest and brings in food for themselves, the queen, and subsequent broods, and the colony grows. However, the percentage of queens that successfully begin new colonies is thought to be very small.

The Difference Between Winged Ants and Winged Termites

Although ants and termites are very different, they are often confused. They are alike in that they live in colonies and periodically swarm. Swarming forms of both are dark and winged. But worker termites are whitish and never seen running freely about as do ants. Instead, termites remain protected in their nests and galleries in wood and soil.

Winged adult ants can be told from winged termites by the following differences. Winged ants have a narrow waist, front wings that are larger than the rear, and elbowed antennae. Winged termites have a fat waist, equally sized wings, and straight, beaded antennae.

Seasonal Abundance

Most outdoor ants increase in population and activity from spring into summer months and then decline from fall into early winter as the temperature drops and the ants' natural food supplies dwindle. Other ants, such as the Argentine ant, may increase in numbers in the fall as various colonies aggregate together to overwinter. Some ants, such as the Pharaoh ant, which may live entirely indoors, exhibit little seasonality.

Feeding Habits

Knowing the food habits of the particular ant species is important in ant management because it may enable the location and elimination of the food that is attracting the ants to the site, it can help to locate foraging trails to track the ants back to their nest, and it can help to choose an effective bait.
Ants feed on many different types of food. Some species will feed on practically anything; others may limit their food to a narrow range. Ants infesting structures are typically feeding on "people food," both food in storage (sugar, cakes, cookies, breakfast cereals, etc.) and food from spills and garbage. But they may also be preying on other insects or scavenging on dead insects in windows or lights.

Food preferences are often seasonal. When the queen is actively laying eggs, worker ants typically gather protein-based foods for the queen. At other times they may ignore protein foods completely and restrict their foraging to sugars and greases.

Many ants obtain sugar by feeding on honeydew, a sweet substance secreted by aphids and other plant-sucking insects. They often defend these insects from predators and tend them as if they were their personal food supply. Indoor infestations of ants are occasionally traced to large populations of aphids on outdoor foundation plants or indoor houseplants.

The six most common ant species that infest buildings are the pavement ant, the thief ant, the crazy ant, the field ant, the Pharaoh ant, and the Argentine ant.

Pavement Ants

Pavement ants (*Tetramorium caespitum*) were introduced to the United States from Europe and occur throughout the eastern United States. They are an important pest in the midwest and New England. These are small ants, about 3/16" long, and are dark brown in color. They build nests along sidewalks, building foundations, and under stones, boards, bricks, and mulch or leaf piles. These ants readily make trails to and from food sources and often forage along the edge of carpeting or baseboards. They are also common around the base of toilets. They often nest in protected areas so the nests may be hard to locate, but this is essential to manage infestations of this species. There can be several thousand in a colony.

Pavement ants feed on a wide variety of foods including other insects, greasy foods, and plants. While they are often found in damp areas, lack of moisture does not limit their development, so solving moisture problems alone will not affect these ants. Vegetation-free borders should be installed around buildings, and any cracks in building foundations should be sealed. Any loose material under that could provide nesting habitats and should be raised off the ground.

Thief Ants

The native thief ant (*Solenopsis molesta*) is found throughout the United States, but primarily in the eastern and central states. A very small ant, thief ants are easily confused with the Pharaoh ant. The best way to tell them apart is to look at the club on the end of the antenna with a magnifying glass and count the number of segments; thief ants have two segments, while Pharaoh ants have three. Thief ants are named for their habit of stealing food from the nests of other ants. They nest outside under debris, rocks, or logs; indoors they nest in wall voids and behind baseboards. They are very small and can easily enter packaged foods, so food should be enclosed in tightly-sealed containers. Locating thief ants' nests can be difficult and time-consuming because their small size can make it difficult to follow the trail. Thief ants feed on both protein and sweets and will tend aphids, mealybugs, and scales to obtain the honeydew they excrete.

All cracks in walls should be sealed to keep these ants from entering buildings. Patience is essential in managing the ants because the nest can be so hard to locate. Baits do not seem to be effective for thief ants since they tend not to eat enough bait to bring sufficient quantities back to the nest for it to work.

Crazy Ants

Crazy ants (*Paratrechina longicornis*) were introduced to the United States from India. Their distribution is limited to the Gulf coast from Florida to Texas. They are easily identified by their long legs and their habit of erratically moving from place to place (hence the name "crazy"). Crazy ant trails are not readily obvious because of this erratic movement. The easiest way to find the nest is to look for workers carrying pieces of food or workers with swollen abdomens. These ants are carrying food back to the nest. By observing their movement, it should be possible to find the nest. Crazy ants are highly adaptable and will nest in a variety of locations, from very dry to moist. They will nest under objects, in rotten wood or trash, in tree cavities, as well as in debris left standing in buildings for long periods of time.

These ants feed on a variety of foods including grease, sweets, and other insects. In some areas they are considered a biological control agent for houseflies. They also tend aphids and scales to feed on their honeydew. While crazy ants need moisture, elimination of water by itself will not get rid of these ants since they can survive under a wide range of conditions. Elimination of food sources and nest sites are equally important in the management of this ant.

Crazy ants do not respond well to baits, so they cannot be relied upon for management of this ant. Surrounding buildings with vegetation-free barriers such as stone or brick (but not wood mulch) will keep ants from entering buildings to nest.

Field Ants

Field ants (*Formica* spp.) are found throughout the United States but primarily in the Midwest and North. They are large (3/8" long) and dark brown to black. They are often confused with the carpenter ant, but can be distinguished by an uneven thorax (see ant identification chart at the end of this module). Field ants feed on other insects as well as insect honeydew. They cause concern because they usually nest near structures and are often mistaken for carpenter ants. Nests are often made in grassy areas and can be difficult to see because they are low to the ground. Field ants will also nest in leaf litter or mulch that is more than two inches thick, and can live under stones, firewood, or other debris that might be found in a lawn area. If pesticide drenches of mounds are used to manage this insect it should be remembered that they will be slow to act because it often takes foraging ants days to return to the nest.

Pharaoh Ants

Pharaoh ants, (*Monomorium pharaonis*), are small yellow ants about 1/16" long. They are easily confused with thief ants, also a small yellow ant. To distinguish the two, it is necessary to look at the antennae. Pharaoh ants have twelve segments with a three-segmented club on the end, while thief ants have ten segments with a two-segmented club. Pharaoh ants are native to tropical Africa but are now distributed throughout the world. They are usually associated with heated buildings since they cannot survive outside year round in the majority of the United States.

These ants will nest in any dark void in a structure as well as in folded bags or newspapers. In subtropical United States they will nest outside in leaf litter, piles of bricks, potted plants, or under roof shingles.

Pharaoh ant colonies can become quite large, often containing as many as 300,000 workers with several queens. New colonies are formed by budding, when some of the workers, brood, and a few queens move to a new location. In warm areas where they can survive outdoors they will move from building to building.

Pharaoh ant management is more dependant on locating areas of ant activity than eliminating the colony, since they are so large and can spread so easily. Place jelly baits on 1" squares of paper or tape and place in damp, dark areas. These ants move along electrical wires, so inspections should include areas where wires enter walls or appliances, and behind switchplates and outlets. Pharaoh ants will also nest in and around appliances such as refrigerators or stoves that have food or water around them. A useful tool for the management is to make a map of the site and mark locations where ants and their colonies are found. This helps identify new areas of activity over time.

Sanitation is essential for Pharaoh ant management, since elimination of food sources will make them more receptive to insecticide baits. Residual insecticides should not be used for Pharaoh ant management. They can repel ants, forcing more colonies to form through budding while killing only a small number of ants. During the first two to four weeks of the program, place baits containing an insect growth regulator and a food attractant inside a soda straw throughout the area of infestation. These should be located along edges and in corners where ants are most likely to encounter them. Placing baits inside straws will keep them fresh and away from people and domestic animals. Replace these with boric acid/food attractant baits. One food bait is three parts honey: two parts peanut butter: one part mint apple jelly : one part egg yolk baby food. Commercial baits are also available. Exterior treatments may be necessary in subtropical areas of the United States or during the warmer months in northern areas.

Argentine Ants

Argentine ants, (*Iridomyrmex humilis*), are an imported species common throughout the southeast and southern California. These ants will nest in soil and mulch, as well as under stones, logs, and debris. They are often found in tree holes, bird nests, leaf litter, and bee hives. These ants form large colonies; workers from different colonies do not fight and will often join together to form larger colonies. This means that areas from which colonies are eliminated can quickly be repopulated. These large colonies will often split by budding during the warmer months. Although Argentine ants form winged reproductives, they do not swarm. They feed on a variety of foods but seem to prefer sweets and will feed on aphid honeydew. They will even feed on fruit crops and are considered an agricultural pest in some areas.

Argentine ant trails are easy to locate along sidewalks, foundations, and along the edges of buildings. If grass grows to the edge of the building it should be pulled back during an inspection. These ants will also move into buildings by climbing up trees onto wires entering buildings, so any place where branches touch buildings should be inspected as well. As with so many other ants, use of a vegetation-free border and correction of moisture problems will help in management of Argentine ants. Insecticide baits are useful for managing this ant.

Occurrence in the Park

Native and exotic ant species occur throughout the NEPE and BIHO area. Pest problems have occured when ants entered residences or other buildings, such as the Spalding Visitor Center (kitchen area), Spalding Maintenance shop, and Big Hole Visitor Center.

Potential Damage and Health Concerns

Harvester ants do not often invade structures but are pests in agricultural crops and have been known to kill young fruit trees. Sometimes these ants undermine the edges of roadways or walkways and causing edges to fail.

Carpenter ants invade structural wood that has been damaged by water. Once nests are begun, the ants are capable of invading peripheral, sound wooden members. If colonies persist for a number of years in a building, considerable structural damage may result.

The odorous house ant is the second most important ant pest in households, only surpassed by the Argentine ant. Bites and stings of odorous house ants may cause allergic reactions or rash in some persons.

Pavement ant workers bite or sting but these ants are not as aggressive as fire ants. They frequently become pests in gardens and are attracted to eggplants, peanuts, and strawberries.

The velvety tree ant invades and damages foam roofs which eventually causes leaks. This is a very aggressive and pugnacious ant. It does not sting but it does bite and then injects poison into the wound. Bites cause severe stinging sensations and are painful.

Thief ants can be very destructive of wood, paper, glue, and other organic materials and present health hazards where they are attracted to food stuffs. Large numbers have been known to kill small chickens but, because of their small size, thief ant bites are not usually serious. Thief ants are the intermediate host of poultry tapeworm. They are persistent, nuisance pests and difficult to control.

Monitoring and Thresholds

This is an infrequent problem and therefore, a monitoring program will only be set up when problems exist and for the specific building.

Identification of the species will help to determine where the nest might be located, what the ants might be feeding on, and the best tactics for control. All parts of the building and the surrounding area should be inspected for ant activity as well as food and water sites. People that work in the building might have seen the ants also. Some species are most active in the evening. For these, a daytime inspection might discover little, while significant ant activity might be observed at midnight.
Some infestations may require an intensive survey program using nontoxic baits to determine likely nesting sites. Good baits are jelly, honey, peanut butter, bacon grease, or raw liver. The baits (or a combination of baits) should be placed on small pieces of cardboard, aluminum foil, masking tape, or plastic pill bottle lids throughout the building and periodically checked for feeding ants. Active sites should be noted on a survey diagram. Baits that haven't had any feeding activity in 24 hours should be moved. Over a period of days the survey diagram will pinpoint areas of activity. In addition, trails of ants feeding on the bait can sometimes be followed back to the nest site.

There is no single threshold level for house-infesting ants. Threshold levels will need to be set separately for each site. A single ant in curatorial or museum areas will trigger control actions. In eating areas, six ants per day. Residences and other buildings will be considered on a case by case basis.

Look for ants and trails along interior baseboards and under the edges of carpets (pull up small areas every 3 or so feet with needle nosed pliers). Especially look for ants under carpets located near sliding glass doors.

In uncarpeted rooms, shine a light under the bottom edges of baseboard and slowly move a knife blade or spatula along in the crack to chase foraging ants into the open.

Carefully inspect sub_slab heating ducts and heating registers. Use a mirror to look into ducts for ants or piles of soil/frass.

Ants often move through plumbing, drain pipe, and electrical line traces that penetrate the slab. In commercial buildings, swarmers often move up through walls and into false ceilings and fluorescent ceiling lights.

To best locate ant trails and be able to follow them, put small amounts of peanut butter and mint jelly on 16 or more (per residence) white, index cards. A day or so before making the inspection, locate the cards throughout the building and In outdoor areas where the occupant has seen ant activity. During the inspection, estimate the number of worker ants on each card, follow ant trails and record other information on an inspection diagram. This survey will show good locations for placement of poison bait stations.

Use pyrethrum flushing sprays to force ants out of hiding along baseboards and other cracks.

Thresholds for actions to control ants vary greatly in regard to sites where ants are found, kind of ants present, and people's general tolerance of ants. Generally, the observation of ants, ant trails, or suspicion of ant nests (especially carpenter ants) located inside a building, residence, or office will be the Action Threshold for controlling ants.

The Action Threshold for harvester ant colonies is finding ant mounds in areas frequently used by visitors or staff and which could result in stinging occurrences.

Non-chemical Control

Past practices of elimination have consisted primarily of attempts to seal entrance points. This has been completed by maintenance personnel.

The most effective ant control results from the destruction of the queens and the nest itself. If the nest is found by tracking workers, or through a survey, eliminating that nest is fairly simple, particularly if it is located, as it often is, outdoors, or in the soil beneath a cracked floor. It is simply a matter of mechanically destroying the nest.

Effective ant management is rarely that simple. Sometimes you can't find the nest. Often there are multiple nests. (One species, the Pharaoh ant, can have hundreds of small nests within a single room.) There may be a constant pressure from ant colonies invading from surrounding areas. In most cases, long-term management of pest ants means integrating improved sanitation, structural repairs, and habitat modification along with one or more direct control tactics such as insecticide baits, crack and crevice treatments, and direct physical controls**.**

Successful ant management usually requires a combination of management tactics, ranging from caulking to cleanup, improved sanitation to habitat modification, as well as targeted and limited insecticide treatment.

The keys to success in ant management are, first, vigorous inspection to determine the nature and extent of the infestation, and, if at all possible, the location of the nest. Second, meticulous sanitation to eliminate readily available food and water. Third, the choice of the right combination of tools to eliminate the problem. The listing for each ant species provides more information on management strategies relevant to that ant.

<u>Improved Sanitation</u>

Like all pests, ants need food, water, and shelter to survive. By limiting these three essentials, you make it more difficult for ants to live in the infested area. Simply by improving sanitation you can often suppress existing populations and discourage new invasions.

Ants can enter many types of food packaging, particularly once the package has been opened. (They have even been found inside glass jars after traveling around the threads of a screw-on lid!) Cereals, sugar, and other bulk food should be stored in plastic containers with snap-on lids, in glass jars with rubber seals, or in a refrigerator.

Food spills also feed ants. As with cockroaches, enthusiastic cleaning helps to minimize ants. Frequent vacuuming, sweeping, or mopping of floors and washing of counter and table tops eliminates much of the food ants may be foraging on. Trash should be stored away from infested areas and monitored for spills.

Ants can get their water from many sources inside a structure: condensation on pipes and air conditioners, leaky plumbing, aquariums, pet dishes, houseplant containers, floor drains, etc., and limiting these is rarely practical.

<u>Ant-Proofing</u>

Ants can enter and move through a structure through innumerable tiny cracks and openings. Yet caulking and otherwise sealing cracks and crevices being used by ants can often have great effect in suppressing the population. Many easy-to-use and effective silicon sealers and expandable caulk products have been recently developed, including some designed specifically for pest management. Repairing torn screens and installing doorsweeps can

also prevent ants from easily entering a structure. Non-vegetation barriers such as stones or brick walkways next to a building can be helpful in helping to keep ants out of structures as well.

Habitat Modification

Trim the branches of trees located close to structures so the branches do not act as runways from nest sites to roof or siding. Alter landscaping to minimize the number of aphids and other honeydew-producing insects that attract ants. Firewood kept indoors should be moved outdoors or regularly inspected for ants. Don't stack wood next to structures and move trash, since ants often nest under objects. Moisture accumulation in buildings can also result in ant infestations.

Direct Physical Control

Ants can be discouraged from foraging in certain limited sites with sticky barriers. For example, commercially available sticky repellents or petroleum jelly can be applied in a narrow band around table legs to prevent ants from walking up to the tabletop. Double-sided tape can also be used.

Large numbers of worker ants can be mopped or sponged up with soapy water. Water, especially boiling water, has also been used to flood ant nests. Some ground-ant nests have been destroyed by digging them up and destroying the nest structure.

Chemical Control

Many people, on discovering ants, simply spray insecticide wherever they have seen ants. This is a poor strategy, usually doomed to failure. Applying undirected, general insecticide sprays is unsatisfactory because the sprays only "harvest" a small portion of the workers and have little effect on the colony, the ultimate source of the problem. A further problem is that some species are triggered into "budding" new colonies when they contact insecticide near their nests or foraging sites.

The chemical tools available for ant control have changed in the past few years with the addition of insect growth regulators, new baits, and commercial bait stations, and new tools can be expected in the future. Even so, insecticides are only one of the tools available for control of ants, and not always the best or most important. Ant biology should be considered when deciding whether or not to use insecticides. For example, insecticides are often not effective against mound ants because it often takes foraging ants several days to return to the nests.

The most effective insecticides for ants are those which kill ants slowly. In this way, worker ants live long enough to take baits back to the nest and feed it to the colony and queen. A bait product that will work against one species of ant may not work against another. It is critical that species are properly identified and insecticides used that work on a species basis.

Chemical pesticides which contain growth regulators such as fenoxycarb or slow acting stomach poisons need to be used in manners which will favor the pesticide reaching the majority of ants in the colony or the queen ant.

Treatments for carpenter ants may require drilling into galleries or wall voids to facilitate the application of boric acid, silica aerogel, or cholopyrifos insecticides. Treatments to outside barriers are sometimes effective in preventing ants from entering structures.

Thief ant nests are difficult to locate, but when found, should be treated with approved pesticides. Carefully apply pesticides into voids, cracks, and crevices, especially concentrating on kitchen areas. Effective sprays and dusts include silica aerogel, boric acid, pyrethrins, chlorpyrifos, diazinon, carbaryl, and bendiocarb. Boric acid baits are available but, to be effective, have to be more attractive to ants than other available food sources.

There are no records of previous control methods used and their effectiveness.

Approved Chemical Alternatives at NEPE:

Allethrin (with piperonyl butoxide) aerosol space treatments for flying insects;
Borate wood treatments for carpenter ants;
Boric acid baits (liquid and solid) for ants, roaches, silverfish, and other indoor pests;
Boric acid dusts for cracks and crevices;
Carbaryl dust for outside pests (carpenter ants, fleas in rodent burrows);
Diatomaceous earth as a dust;
Diatomaceous earth dusts with pyrethrins;
Methoprene insect growth regulator for fleas, ants;
Pyrethrin contact sprays;
Silica aerogel for dusting cracks and crevices and along pathways used by pests;
Silica gel with pyrenone for cracks and crevices.

Other chemical alternatives that must have prior approval include:

Chlorpyrifos for carpenter ants in wood; outside pests;
Diazinon for outdoor pests;
Fenoxycarb insect growth regulator for ants, fleas, roaches;
Glyphosate for herbaceous and woody weed control against structures;
Hydramethylnon baits for ants, roaches, and crickets;
Malathion for outdoor pests;
Potassium salts of fatty acids (soaps) for insects on plants;
Resmethrin aerosols space treatments, honey bees; outside applications.

Resources

Materials Available

Materials available include common sense items such as doors, window screens, and basic sanitation procedures.
Technical Experts

Since these instances are of such an occasional manner, no technical experts are listed. The best place to start would be to consult with the County Extension Agent for the area.

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BEAVER

Common Name

The beaver (*Castor canadensis*) is found throughout most of North America except in the Arctic tundra, peninsular Florida, and the Southwestern deserts.

Identification and Biology

Beavers commonly inhabit riparian areas of mixed coniferous-deciduous forests and deciduous forests containing abundant beaver foods and lodge building material such as quaking aspen (*Populus tremuloides*), willows (*Salix spp*.), alders (*Alnus spp*.), red-osier dogwood (*Cornus sericea*), and cottonwoods (*Populus spp*.).

Breeding occurs between January and March. Beavers are generally monogamous, although males will mate with other females. Only the colony's dominant female breeds, producing one litter a year.

Gestation period lasts 4 months. Average litter size varies between 2.3 and 4.1. Kits are weaned at 2 to 3 months and can swim by 1 week of age. Beavers become sexually mature between age 2 and 3.

The colony consists of three age classes of beavers: the adults, the kits, and the yearlings born the previous spring (average 5.1 beavers per colony). After young beavers reach their second or third year, they are forced to leave the family. Dispersal may be delayed in areas with high beaver densities. Subadults generally leave the natal colony in the late winter or early spring. Subadult beavers have been reported to migrate as far as 147 miles (236 km), although average migration distances range from 5 to 10 miles (8-16 km).

Beaver live up to 11 years in the wild, 15 to 21 years in captivity.

Beaver are active throughout the year and are usually nocturnal. Adult beavers are nonmigratory.

Suitable habitat for beavers must contain all of the following: stable aquatic habitat providing adequate water; channel gradient of less than 15 percent; and quality food species present in sufficient quantity. Beavers can usually control water depth and stability on small streams, ponds, and lakes. Large lakes or reservoirs (20 acres [8 ha] in surface area) with irregular shorelines provide optimum habitat for the species. Lakes and reservoirs that have extreme annual or seasonal fluctuations in the water level are generally unsuitable habitat for beavers. Intermittent streams or streams that have major fluctuations in discharge will have little year-round value as beaver habitat.

Stream characteristics such as gradient, depth, and width are determining factors in habitat use by beaver. Steep topography prevents the establishment of a food transportation system. Additionally, narrow valley bottoms cannot support the large amounts of vegetation needed by beavers. Consequently beaver populations in narrow valley bottoms are more cyclic than are populations in wider valley bottoms. Valleys less than 150 feet (46 m) wide are occupied less frequently. One study found that 68 percent of the beaver colonies recorded in Colorado were in valleys with a stream gradient of less than 6 percent. No beaver colonies were recorded in streams with a gradient of 15 percent or more. Valleys that were only as wide as the stream channel were unsuitable beaver habitat, while valleys wider than the stream channel were frequently occupied by beavers.

Food availability is another factor determining suitable habitat for beavers. Marshes, ponds, and lakes are often occupied by beavers when an adequate supply of food is available. Beavers generally forage no more than about 300 feet (90 m) from water; however, foraging distances of up to 656 feet (200 m) have been reported.

The lodge is the major source of escape, resting, thermal, and reproductive cover for beavers. Lodges may be surrounded by water or constructed against a bank. Water protects the lodge from predators and provides concealment for beavers when traveling to and from food gathering areas and caches. On lakes and ponds, lodges are frequently situated in areas that provide shelter from wind, waves, and ice. Damming large streams with swift, turbulent waters creates calm pools for feeding and resting.

Beavers are herbivores. During late spring and summer their diet consists mainly of fresh herbaceous matter. Beavers appear to prefer herbaceous vegetation over woody vegetation during all seasons if it is available. Woody vegetation may be consumed during any season, although its highest utilization occurs from late fall through early spring when herbaceous vegetation is not available. The majority of the branches and stems of woody vegetation are cached for later use during the winter.

Winter is a critical period, especially for colonies on streams because they must subsist solely on their winter food caches. In contrast with stream beavers, colonies on lakes are not solely dependent on their stores of woody vegetation; they can augment their winter diet of bark with aquatic plants.

Aquatic vegetation such as duck-potato (*Sagittaria spp*.), duckweed (*Lemma spp*.), pondweed (*Potamogeton spp*.), and water weed (*Elodea spp*.) are preferred foods when available. The thick, fleshy rhizomes of water lilies (*Nymphaea spp*. and *Nuphar spp*.) may be used as a food source throughout the year. If present in sufficient amounts, water lily rhizomes may provide an adequate winter food source, resulting in little or no tree cutting or food caching of woody materials. Other important winter foods of beavers living on lakes include the rhizomes of sedges and the rootstocks of mat-forming shrubs.

Important woody foods of beavers include quaking aspen, willow, cottonwood, alder, red maple (*Acer rubrum*), serviceberry (*Amelanchier spp*.), mountain maple (*Acer glabrum*), red-osier dogwood, and green ash (*Fraxinus pennsylvanica*). Other woody species occasionally utilized for food include sugar maple (*Acer saccharum*), black ash (*Fraxinus nigra*), yellow birch (*Betula alleghaniensis*), hazels (*Corylus spp*.), hemlocks *(Tsuga spp*.), and Oregon crab apple (*Malus fusca*). Aspen and willows are considered preferred beaver foods; however, these are generally riparian tree species and may be more available for beaver foraging but not necessarily preferred over all other deciduous tree species. Beavers have been reported to subsist in some areas by feeding on conifer trees; however, these trees are a poor quality source of food.

Woody stems cut by beavers are usually less than 3 to 4 inches (7.6-10.1 cm) in d.b.h. One study reported that trees of all size classes were felled close to the water's edge, while only smaller diameter trees were felled farther from the shore. Trees and shrubs closest to the water's edge are generally utilized first.

Beavers have few natural predators. However, in certain areas, beavers may face predation pressure from wolves (*Canis lupus*), coyotes (*Canis latrans*), lynx (*Felis lynx*), fishers (*Martes pennanti*), wolverines (*Gulo gulo*), and occasionally bears (*Ursus spp*.). Alligators, minks (*Mustela vison*), otters (*Lutra canadensis*), hawks, and owls periodically prey on kits. Humans kill beavers for their fur.

Occurrence in the Park

Beaver may be found in all areas of the park that have suitable habitat, but have been observed at Spalding, White Bird Battlefield, and Big Hole National Battlefield.

Potential Damage and Health Concerns

Beaver activity can have a significant influence on stream and riparian habitats. Beavers are the only mammals in North America other than humans that can fell mature trees; therefore, their ability to decrease forest biomass is much greater than that of other herbivores. Additionally, beaver ponds conserve spring runoff, thus ensuring more constant stream flow, diminishing floods, conserving soil, and helping maintain the water table.

Through tree harvesting activity, beavers can have an effect on natural succession. Beavers are selective in their choice of woody plants, preferring some woody species over others.

Beaver activity can be beneficial to some wildlife species. Waterfowl often benefit from the increased edge, diversity, and invertebrate communities created by beaver activity. Occupied beaver-influenced sites produce more waterfowl because of improved water stability and increased brood-rearing cover; the production declines with beaver abandonment. Great-blue herons (*Ardea herodias*), ospreys (*Pandion halietus*), eagles (*Haleaeitus leucocephalus*), kingfishers (*Ceryle alcyon*), and many species of songbirds benefit from beaver activity as well.

Otters, raccoons (*Procyon lotor*), mink, and muskrat (*Ondatra zibithica*) thrive on the increased foraging areas produced by beaver activity. Berry-producing shrubs and brush in areas cut over by beavers attract white-tailed deer (*Odocoileus virginianus*) and black bear (*Ursus americanus*).

Beaver activity can also improve fish habitat. Production of three trout species (*Salmo spp*. and *Salvelines fontinalis*) in a stream in the Sierra Nevada increased due to a higher standing crop of invertebrates in beaver ponds.

The amount of influence that cattle have on riparian environment can be reduced by beaver activity in many valley bottoms. If beavers are thoroughly established in wide valley willow habitats prior to the introduction of cattle, the immediate effect of cattle on the stream is often minor .

In areas of marginal trout habitat, however, beaver activity can reduce trout production. Beaver-caused loss of streamside shade and diminished water velocity can result in lethal water temperatures.

Beaver activity can also have detrimental effects. Beaver-caused flooding often kills valuable lowland timber. Human/beaver conflicts occur when beavers flood roadways and agricultural lands, and dam culverts and irrigation systems. The economic cost of nuisance beaver activities often exceeds the value of their pelts and has been estimated at $75 to $100 million annually in the United States. Additionally, beavers have potential to increase water-borne pathogens (including *Giardia lamblia*) downstream from their activity.

Beaver activity may also contribute to degradation of historic and cultural scenes by habitat modification.

Monitoring and Thresholds

Inspection and monitoring of beaver damage is concurrent. Frequently observe streamside and riparian areas for signs of shrub/tree cutting activity and dam building. If frequent degradation occurs or if large areas are damaged, clearly identify the characteristics.

Frequent or costly damage to shrub and tree species, flooding of historic/cultural areas or damage to the same will be the action threshold for beaver control. In the late 1980's and early 1990's, managers at Big Hole National Battlefield were concerned about the potential impacts of beaver in the North Fork of the Big Hole River. No evidence of control or other action has been found.

Beaver are native animals and in most cases should be left unmolested. Action thresholds may be triggered when control is necessary to prevent habitat degredation or protection of other park resources.

Non-Chemical Management

Probably the most effective tool of non-chemical management is to reduce the area of potential damage. Prescribed fire is a tool that can effectively reduce available beaver habitat.

Scare devices and repellents are not effective methods of beaver control. Live trapping may provide some relief, but cooperative agreements must be in place with agencies or land owners where the animals may be moved to. Use a “Hancock live-trap”, baited with apple, aspen, or willow.

Harpoon traps are the most effective for taking of beaver, but must be securely staked so the beaver do not drag the trap. Baiting with apple, aspen, or willow wood is effective. Again, the most favorable option is to reduce or alter habitat in such a way that beaver are not encouraged.

Chemical Control

Ro-Pel may be used for repelling beaver from areas for small amounts of time.

Approved Chemical Alternatives at NEPE:

Ro-Pel.

Resources

Materials Available

No materials available.

Technical Experts

Contact the local fish and wildlife management office for informaiton

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BURROWING RODENTS

Common Names

All of these mammals are extremely proficient in burrowing and creating extensive tunnel systems.
There are many species of ground squirrel in the western United States, with Richardson's (*Spermophilus richardsonii*), Columbian (*S. Columbianus*), thirteen lined (*S. tridecemlineatus*), and golden-mantled ground squirrel (*S. lateralis*) distributions potentially overlapping NEPE and BIHO areas.

Identification and Biology

Ground squirrels have short grayish fur above with pale underbodies with a short tail. They rarely have stripes, but if so, not on the head. Ground squirrels are all burrowers and colonial in nature. These rodents hibernate during the cold winter months, but may occasionally appear on warmer days. They mainly feed on seeds, hence the name "spermopholites". They will also feed on green plants, bulbs, and insects (grasshoppers, crickets, and caterpillars).

Ground squirrels breed in during the winter and young are born in the early summer, May and June, with from 2 to 12 being born, depending on the species.

They prefer open prairies, grasslands, meadows, and brushy areas.

Predators include coyotes, badgers, bears, weasels, hawks, and rattlesnakes.

Only the coast mole (*Scapanus orarius*) may be found on NEPE areas, and is restricted to the western Idaho and Oregon areas.

Moles generally prefer deep, soft soils and may be found in woods, grasslands, meadows, and manicured lawns.

Moles are small, streamlined burrowing mammals, with velvety fur, light-sensitive eyes, short tails, and enlarged front, out-turned claws. These claws allow moles to "swim" through porous soft soils, leaving ridges along surface traces of movement. They also will leave cone-shaped molehills, usually 6 to 8" high, especially during wet weather.

Moles have an annual litter rate of only 1 per year with 2 to 6 young, born in the early spring.

Moles eat primarily invertebrates, such as worms, but will take small amounts of plant material.

There are few natural predators of moles, since they rarely come out of their subterranean habitat.

Several species of voles may be found in the NEPE and BIHO area. The southern red-backed (*Clethrionomys gapperi*), heather (*Phenacomys intermedius*), meadow (*Microtus pensylvanicus*), montane (*Microtus montanus*), long-tailed (*M. longicaudus*), prairie (*M. ochrogaster*), water (*Arvicola richardsoni*), and sagebrush voles (*Larurus curtatus*) all are potential inhabitants.

Voles are mouse-sized rodents that build runways and burrows, usually in dense vegetation. Voles have short ears, fur and tails, and may exhibit a variety of coloration from reddish to black.

The montane vole is consistently found in dry grassy areas and may pose a problem with extensive runway and burrow systems, usually under grassy cover.

Hawks, owls, weasels, and snakes are the primary predators.

Pocket gophers occur only in North America. The only species found in the NEPE and BIHO areas is the Northern pocket gopher (*Thomomys talpoides*). Pocket gophers have thick bodies, short necks, short fur, small eyes and ears, and naked or sparsely haired tails. They also have external, fur-lined cheek pouches, or pockets. Pocket gophers

leave characteristic high fan-shaped mounds of dirt in the spring or other seasons of the year. They do not hibernate during the winter months, but retreat to deep burrows.

Habitat is usually good soil in meadows or along streams of mountains or lowlands.

Pocket gophers mate in the spring and there may be 1 or 2 litters born per year, with from 2 to 11 young.

Predators are badgers, weasels, and gopher snakes.

The tunneling activity of all these mammals, while appearing as a nuisance, is a benefit to soil aeration and moisture penetration, thus reducing the damages of soil erosion.

Occurrence in the Park

Ground squirrels occur on the Montana sites. Moles occur in Idaho and Oregon. Voles and pocket gophers may be present at all sites.

Potential Damage and Health Risks

The main damage from burrowing animals is to manicured lawns and established trails. Burrowing activity may become unsightly and creates public safety and maintenance problem on trails. These rodents may also be vectors for infectious diseases.

Monitoring and Thresholds

Inspection and monitoring of burrowing animal damage is concurrent. Frequently observe manicured lawns for signs of borrowing activity. If frequent degradation occurs or if large areas are damaged, clearly identify the characteristics.

Frequent or costly damage to manicured lawns, other cultural or natural resources, or threats of human injury through trail degradation will be the action threshold for burrowing rodent control. In these instances, control measures should be aimed at individuals and not populations, since these are native species.

Non-chemical Management

Probably the most effective tool of non-chemical management is to reduce the area of potential damage. Reduce the area of affected areas by evaluation of manicured lawns and trails necessary to accomplish the purpose of the park. If a "natural" setting is desired, then the burrowing of an animal is not a problem.

Scare devices, repellents, and shooting are not effective methods of burrowing rodent control.

Live trapping may provide some relief, but the animals should be released on NPS property and with the small acreage at NEPE and BIHO, the animals may return to the same areas and begin the damage again. Live trapping is difficult with moles and pocket gophers since they do not readily enter traps. Live trapping of ground squirrels is not an effective method of population reduction, since only small portions of populations can be trapped.

For taking or killing ground squirrels, a variety of traps and sizes may be utilized. Rat traps, leg-hold (#0, 1, 1 ½), Havahart (#2, 2A), Tomahawk (#103, 104), or Conibear (#110-2) may be used with nuts or peanut butter as a bait. Traps are placed in or near burrow openings and tied to vegetation of a stake to prevent injured animals from dragging the trap under ground.

Moles, voles, and pocket gophers are most successfully captured with Victor harpoon traps placed in an active mole-hill. The trap is placed in the burrow path and partially buried so the mole will have to push dirt through the trap to be captured. This necessitates watching the hill for activity, placing the trap in the evening and checking the trap the following morning. No bait is used.

Pocket gophers may also be trapped with Macabee, California, Gopher-getter, box, and pincer traps.

Chemical Control

Carbon monoxide gas fumigation cartridges (Gopher-Gasser) for fumigation of burrows if persistent damage occurs to manicured lawns or trails in visitor use areas.

Zinc phosphide (Hopkins zinc phosphide) for placement around burrow openings of pocket gophers, voles, and moles in manicured lawn areas.

Carbaryl dust (sevin) dusting of burrow entrances in the event of notification by CDC of human health hazard due to fleas.

Approved Chemical Alternatives at NEPE:

Zinc phosphide (Hopkins zinc phosphide) for placement around burrow openings.

Other chemical alternatives that must have prior approval include:

Carbaryl dust (sevin) dusting of burrow entrances;
Carbon monoxide gas fumigation cartridges (Gopher-Gasser)**.**

Resources

Materials Available

The park has a variety of traps that may be used.

Technical Experts

Contact the local fish and wildlife and/or County Extension Agent for the area.

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COCKROACHES

Common Name

There are over 50 species of cockroaches in the United States, but only four are regarded as common household pests. These are the German (*Blatella americana*), brown_banded (*Supella longipalpa*), American (*Periplaneta americana*), and Oriental (*Blatella orientalis*) roaches. All 4 of these species have world_wide distribution.

The importance of cockroach control can not be taken lightly. Cockroaches are said to be the most significant household insect pest and directly affect more people in this country than any other group of insects. Many urban residents who have fought roaches with insecticides for years are usually very skeptical of ever being able to control them. Roach control is difficult because 95 or more percent of the roaches in a building must be eliminated or a roach population recovers to pre_treatment levels in just a few weeks. Most failures in control are because 1 or more key roach habitats were not found and treated, and also German and brown_banded roaches can be continually imported into buildings along with paper items, cardboard boxes, furniture, electrical appliances, and other goods.

German cockroach

The German roach is more active than other domestic roach species, is the most frequently encountered roach, and is potentially more fecund than other species. Adults are about ½ to $^{5}/_{8}$_inch in size and light brown to tan in color. The most distinguishing characteristic that identifies them is two dark, parallel stripes running lengthwise along the pronotum. German roaches have wings and can glide (fly) short distances.

German cockroaches can be found throughout a structure but most commonly in those rooms where people eat and drink. German roaches tend to prefer warm, humid sites (kitchens and bathrooms) where their main harborage is in structural cracks and crevices located near sources of food and/or water. The insects produce aggregation pheromones which attract other roaches into safe and favored sites for feeding and resting.

German roaches tend to remain closer to harborage (10 to 15 feet) than Oriental or American roaches (50 or more feet), and spend 75 percent of their life resting in cracks. Small instar (young, still developing) roaches can use cracks as small as $^{1}/_{64}$_inch wide but larger adults require crevices about $^{3}/_{16}$_inch wide. Female roaches are usually quite active but gravid females may never leave a crack, even to feed. Males seldom leave deep cracks and nymphs remain in hiding before and during molt. Periods of inactivity tend to reduce the effectiveness of pesticide sprays or baits placed out in open areas of the room.

Female German roaches produce 5 to 6, yellowish_brown egg capsules, about $^{1}/_{4}$ to $^{3}/_{8}$_inch long, during their lifetime (100 to 200 days). Each egg capsule contains about 30 to 40 eggs. Females carry an egg capsule until it is within a couple of days of hatching and then deposit it in a sheltered site. Females are often seen with the egg capsule still attached and protruding from their posterior end. Varying temperatures and humidity influence the length of time it takes for eggs and young to develop into mature insects but the range is usually from 2 to 7 months. Well_established populations are typically composed of about 75 percent nymphal roaches. A German roach population, given favorable conditions, can increase by at least 2000 percent in 3 months. Serious household infestations can quickly develop after introducing only a few individual roaches.

German roaches prefer foods that are high in carbohydrates such as powdered sucrose, maltose, dehydrated potatoes, and alcohols (especially beer). However, they will feed on almost anything having nutritive value which includes all types of food products as well as soap, glue, paper, and toothpaste.

Brown_banded cockroach

Adult brown_banded roaches are about ½_inch long, light brown in color, and have two faded, light_brown stripes across the top of their wings. Females are darker than males. The pronotal shield is in the shape of a "liberty bell". Similar to adults, nymphs also have light tan stripes across the back.

The brown_banded roach is gregarious, but, different from German roaches, shows a preference for high, dry, and

warm locations with low moisture such as shelves in closets, behind picture frames and wall hangings; under wall moldings; near appliance motors; and in light switches, closets, and furniture. This roach prefers temperatures around 80_F. and temperatures lower than 75_F. retard its development. Brown_banded roaches are difficult to control because they may have such wide distribution within a structure. And, since both sexes can fly with well developed wings, they can readily move throughout a building.

Brown_banded roach egg cases are small ($^{5}/_{32}$ to $^{3}/_{16}$_inch long), reddish brown, and purse shaped. Unlike German roaches, a female brown_banded roach only carries an egg case for 24 to 36 hours and then deposits it, usually in or under furniture or shelving. The preference for placing egg cases within furniture helps to account for the wide_spread national distribution of this roach.

Females live about 7 months during which time they produce about 14 egg cases, each containing 14 to 18 eggs. Development from the egg to adult is greatly influenced by temperature and averages about 5 months but can vary from 3 to 9 months.

Brown_banded roaches prefer starchy foods like bread crumbs, book sizing, and wallpaper paste but will also feed on and damage a number of other items, even nylon stockings. Brown_banded roaches have lower water requirements than other roaches and can occupy a greater variety of sites in a building.

American cockroach

The American cockroach is the largest cockroach in this country averaging about 1_$^{1}/_{2}$ _inches long. Because of their size, American roaches are able to carry large pieces of food away to protected places where they eat it. Foods not eaten by American roaches sometimes attracts other insect pests.
The American roach has reddish_brown wings lightly marked with yellow around the perimeters and long antennae (1 to 1-½ times the length of the body). Adults have fully developed wings but do not commonly fly. Economically, the American roach is the second_most significant roach in this country (the German roach being the first).

The American cockroach normally lives outdoors in alleys, lawns, decayed wood, and palm tree fronds but becomes an important structural invader, especially in warmer areas of the country, because it has become so well established in sewers. After entering structures, the American roach thrives in dark, moist, warm (about 80_F.) sites like kitchens, bathrooms, basements, furnace rooms, steam tunnels, sewers, and crawl spaces. It is not often found on second floor levels of buildings.
American roaches easily enter buildings through sewers and drains when drain traps do not contain water, through open pipe and electrical traces, or under doors. American roaches, however, do not usually range very far (20 yards being an unusual distance) and the site of their entrance can usually be determined by the relative numbers caught on sticky traps. American roaches frequently invade buildings in large numbers following heavy rains or when waste water drainage systems back up.

The American roach is principally an outdoor species where it feeds on decaying vegetation, leaf litter, wastes, and other dead and decomposing organic matter.

Females produce about 9 to 10, $^{3}/_{8}$_inch long, dark reddish_brown egg capsules during their life. Each egg capsule contains about 16 eggs. Usually, the female produces 1 capsule per week until she has placed about 15 to 25 capsules in different locations near food sources. The female deposits the egg capsule soon after it is formed and does not carry it like German roaches. Eggs hatch in about a month and nymphs take from 5 to 26 months to mature, depending on temperature. There is usually only 1 generation of American roaches produced per year but adults can live for up to 3 years. American roach populations tend to cycle with the season and their numbers usually increase about the same time each year.

In many parts of the country, nymphal American roaches begin to hatch during May and June when populations contain about an equal number of adults and nymphs. Their populations tend to reach the greatest numbers between August and November when nymphs outnumber adults.

American roaches feed on almost all household foodstuffs but foods with saturated fatty acids increase their feeding. Even though these roaches are serious pests in residences, they are even more commonly found in commercial establishments as bakeries, restaurants, and grocery stores where they live in food storage and food preparation areas, drains, damp basements, and steam tunnels.

Oriental cockroach

Oriental cockroaches are dark, shiny, reddish_brown to black roaches. The females may be as large as 1 _$^{1}/_{4}$_inches long and are slightly more robust than 1_inch_long males. Wings on males extend $^{2}/_{3}$ to $^{3}/_{4}$ the length of the body but female wings are only rudimentary, stubby lobes. Neither sex can fly at any age. The antennae of both sexes are about as long as the body. When disturbed, Oriental roaches seem sluggish and do not appear to move as quickly as do other roaches. Oriental roaches lack the specialized pad on their feet which allows other roaches to climb on smooth surfaces.

Oriental roaches can survive outdoors in most geographic areas and are found under stones, debris, and leaf litter _ even during mildly freezing weather. They mainly enter buildings through sewer drains, under doors, and along pipe and electrical line traces. Oriental roaches have high moisture requirements and are usually only found in the lower areas of a structure such as basements, crawl spaces, and lower wall voids. However, it is not unusual for Oriental roaches to travel along water pipes and electrical lines and appear in upper floor levels.

An adult female lives for up to 6 months. During that time she can produce about 8 reddish_brown (which later turn black), $^{3}/_{8}$_inch long egg cases, each containing about 16 eggs. The female deposits an egg case in a protected site within about 30 hours of its formation. Eggs take from 1 to 3 months to hatch and development from nymph to adult can range from 7 to 26 months, depending on temperature. Most nymphal roaches become adults during May and June which are peak months when Oriental roaches move indoors.

Oriental roaches mostly feed on a wide variety of organic matter. Reducing available food is not usually an effective method for controlling Oriental roaches because they can find so many other, naturally_occurring foods such as dead insects, slugs, and animals; grass and weeds; bird and animal droppings; and human garbage.

Adult numbers are highest from spring to late June and nymphal roach numbers are highest between late_July and August. September populations are mostly composed of small to mid_sized nymphs and only contain a few adults. Nymphs that hatch in late fall overwinter and then mature during late spring. These cycles may give false impressions of the effectiveness of control. During late fall, after the natural die_off of adults and populations seem to be controlled, nymphs continue to increase in number in voids and crawlspaces until crowding forces them out into view.

Roaches are prey for ants, rats, wasps, toads, beetles, bugs, mantids, dragonflies, cats, spiders, lizards, birds, rats, and mice.

Occurrence in the park

Although there have been no problems in park buildings in the recent past, cockroaches are a potential problem. Roaches may be found in any building where sanitation is low, and where water and harborage is adequate for survival.

Potential damage and health concerns

Roaches are responsible for spreading many serious diseases, pathogens, and parasitic organisms. Roaches constantly vomit and deficate on materials they travel across, thus potentially spreading any disease carried to associated surfaces.

Roaches carry diseases from sewers or other areas into homes and buildings and spread these to humans. Roaches vector fecal streptococci, staphylococcus, clostridium, salmonella, proteus, bacillary dysentery, typhoid fever, cholera, polio, amebic dysentery, urinary tract infections, diarrhea, and infectious hepatitis. They are also know to be responsible as a source of sever cases of human allergies, especially in children.

Roaches will invade bedrooms and climb on sleeping persons to gnaw on proteinaceous material such as eyebrows, hair, or calluses. They have even been known to enter ear canals, requiring medical attention for removal.

Electrical switches are particularly attractive to roaches, where their body fluids corrode contact points and set off alarm systems, disrupt cash registers, and cause short circuits in computers. The hard exoskeleton of a roach can also scratch sensitive computer heads and disks.

Roaches feed on and damage a variety of materials. Some of these are paper, glues, clothing, furniture, food stuffs, molds, and any other item that may provide food. Through vomiting, defecation, and body secretions, roaches spoil a tremendous amount of foodstuff.

Monitoring and Thresholds

Inspections and monitoring for roaches are critical. Cockroach inspections should determine the kind(s) of roaches present in a structure, the relative size of their population, and the underlying reasons of the problem. Knowledge of pre_treatment and post_ treatment population size is necessary to be able to properly evaluate the effectiveness of control.

Use a bright flashlight when inspecting areas to find the focal areas of cockroach activity. Nighttime inspections made with a yellow filter covering the inspection light can be very effective. Applying fluorescent sticky labels to suspected harborage sites during daytime inspections will make those sites easier to find after dark.

Sticky traps are the most commonly used method to determine the presence and abundance of roaches in a structure. One study showed that there is probably a minimum of 800, and possibly as many as 2,000, roaches in a dwelling for every individual trapped during a 24_hour period. Serious roach problems can exist when more than 1 to 2 roaches are trapped during any 24 hour period.

When placing sticky traps, individually number the traps and note their location in the structure on a floor plan diagram. Analysis of captures will show major roach harborage areas and where to make treatments. The most important data to record for sticky traps is the total number of roaches caught; however, additional information on the presence of egg capsules and immature roaches provides valuable insight into population trends (see sample form at the end of this section). Also record any recommendations for new treatments or changes in Action Thresholds, capture of insects other than roaches, evidence that roaches or other insects that have been eaten by rodents, captured rodents, and record any missing traps (lost to vandalism or removed by animals or maintenance workers).

Sticky traps should be repositioned if no roaches are caught after 2 or 3 nights. The number of traps required varies with the species of roach present and the severity and location of infestations. Use at least 10 sticky traps per 100 square feet of room size, but also place 5 traps in each potential area of major activity (under sinks and dish washing machinery, around sources of food, water, warmth, etc.). Some commercially available sticky traps come supplied with attractive food tablets that are more effective than unbaited traps. Peanut butter placed in the center of a sticky trap can also be used as an attractant. Place sticky traps against walls and fixtures and under appliances but not out in the open; and, do not place traps where they will get wet. The best locations for traps are in areas showing signs of roach activity (stains and feces). Leave traps out for 2_3 nights. When roaches are captured on traps, study their position on the trap to indicate the direction from which they entered the trap. Often this information can be plotted to point out major areas of activity. Some roaches can complete a generation in 4 to 6 weeks, therefore follow_up monitoring is always required.

German and Oriental roaches are attracted to tight, dark spaces such as beneath boards. An effective sticky trap for these species is a standard glue board (as used for mice) placed sticky side down and separated from the floor with 3/16_inch thick spacers (small coin).

The Action Threshold will be 1 roach trapped in sticky traps over a 24 hour period.

Non_chemical management

The first step to roach control is proper identification of the species. A knowledge of the species present will allow the control program to be more specific and effective.

As with many other pests, exclusion is requisite. Seal all entry points such as cracks, crevices, windows, door sweeps, pipe and electrical opening, drains, ventilation ducts, and any other entrance point possible.

Store foodstuffs in containers with tight fitting lids. Clean kitchen areas immediately after use, making sure all counters, appliances (ovens, refrigerators, microwaves, toasters, coffee machines, etc.), and floors are clean and dry. Do not leave dirty dishes in sinks. Keep pet food and dishes clean. Do not leave pet food dishes out between feedings. Remove food from drawers, even in offices. Do not cover shelves with paper as this provides harborage. Repair leaks or other sources of condensation. Place wet garbage in plastic bags before disposal. Maintain tight fitting lids on garbage cans and empty daily. Do not store empty, recyclable aluminum cans or plastic containers indoors.
Examine all boxes, bags, food, or other containers for roaches, egg casings, or signs of other pests before bringing them indoors.

Do not store anything in areas that will create hiding places for roaches. Where possible, store materials off the floor. Hang mops, brooms, and other cleaning tools by the head. Remove harborage such as debris, wood, branches, etc. from around the outside of structures. Store firewood on pallets off the ground and only take the amount of wood indoors than will be used immediately. Trim vegetation so as to not touch structures.

There are a variety of non-poisonous traps that will catch a significant number of cockroaches. Trapping will only reduce infestations by small amounts. Two effective, homemade traps are:

_ Place about ½_inch of beer or a mixture of 1 part molasses to 10 parts water in a pint jar and locate the jar where roaches can reach it. Insects that enter the jar will drown in the liquid.

_ Place one inch of water with a few drops of detergent in the bottom of an empty jar and lightly coat the inside of the jar with peanut butter. Roaches will drown in the water.

Chemical management

Remember that exclusion and sanitation are the primary controls for roaches. Chemical controls will only provide temporary control measures. Once the residual effects of chemicals have diminished, roaches will reinvade inside areas if exclusion and sanitary efforts are not maintained.

Chemical application need to be made to those area where roaches breed and hide (cracks and crevices). The most effective and least dangerous chemicals for roach control in these areas are silica aerosol dusts, boric acid, and diatomaceous earth. These are effectively applied by using plastic squeeze type containers. Boric acid may take from 7 to 14 days to kill roaches, where silica aerogel and diatomaceous earth are faster. These materials remain active for extensive periods of time and roaches show no resistance to them at present. Pyrethrin, baygon, diazinon, and dursban dusts or sprays are also effective on roaches.

Boric acid and hydramethylnon baits are probably the most effective chemicals for roach control. If these are used, enough stations must be placed so as to adequately cover the area and provide the effects desired. This means that in an average sized kitchen, a minimum of 10 or more stations should be placed along walls, under shelves, and even on vertical surfaces such as walls and cupboards.

Insect growth regulator chemicals are available either as dusts, baits, or disposable packets that release very small amounts of the material into the air.

Resmethrin_based aerosol sprays are effective for a quick knock_down of large roach populations, however they are not long lasting and do not penetrate into hiding places.

Residual insecticides may be applied to outside cracks, crevices, pipes, electrical traces and other holes, and these can be then sealed with caulking. Hydramethylnon bait stations can be placed in attics or crawl spaces, or residual pesticides may be used to dust these area under high population occurrences.

The principal products for roach control in sewers are silica aerogel, bendiocarb, chlorpyrifos, and carbaryl dusts. Silica aerogel, used at the rate of 136 grams per manhole in Yakima, Washington, proved very effective and is considerably less toxic than the other chemicals.

Approved Chemical Alternatives at NEPE:

Allethrin
Boric acid
Diatomaceous earth
Fenoxycarb (IGR)
Permethrin
Pyrethrum and pyrethins
Silica aerogel and silica gel

Other chemical alternatives that must have prior approval include:

D_phenothrin
Hydramethylnon
Hydroprene (IGR)
Resmethrin

Resources

Materials Available

Materials available include common sense items such as doors, window screens, and basic sanitation procedures.

Technical Experts

NPS-WASO IPM Coordinator, Columbia Cascades Cluster IPM Coordinator, and/or the County Extension Agent for the area.

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COCKROACH STICKY TRAP MONITORING FORM

BUILDING:			**INSPECTOR:**				
LOCATIONS			**CAPTURES**				
DATE	**LOCATION**	**TRAP NO.**	**ADULTS**	**IMMATURES**	**EGG CASES**	**TOTAL CAPTURES**	**NOTES**

Analysis:
* Infestations composed entirely of German and brown_banded roaches indicates that the insects are not coming in from outdoors.
* Samples which include only American and Oriental roaches indicates roaches are moving into the building from the outside.
* Oriental roaches found on upper floors suggests insects are moving up from the basement or sewer through wall voids or pipe and electrical traces.
* Look at the direction roaches entered a sticky trap and plot those directions back to suspected harborage areas.
* If only roach (or other insect) parts (i.e. legs, antennae, fecal piles) are found on sticky traps, mice are probably eating the captured roaches.
* American roaches in a tight basement suggests insects may be entering through sump pumps located below the basement floor. Check basement floor drains. Ask maintenance to open sumps for inspection; look into lateral lines emptying into sumps and at any water or steam pipes penetrating basement walls. Cavitation may be present around pipes or on the earth_side of the basement wall. Apply non_repellent baits or boric acid dust in drains to prevent flushing the roaches into structural interiors.
* Adult roaches can move for some distance from harborage to sticky traps. If only young nymphal roaches are seen on traps, the harborage is probably located close to traps. If roaches in all stages of development are seen on traps (young nymphs to adults), it is almost certain that roaches are breeding on the premises and are not coming in from the outside. Ask long_time residents or cleaning or maintenance personnel about any possible old roach harborage that is now hidden by newly_installed paneling or equipment.

From: Hoddenbach, Gerard A. 1996. Integrated Pest Management Plan for Big Bend National Park. PO Box 128, Torrey UT 84775.

DEER

Common Name

White_tailed (*Odocoileus virginianus*) and mule deer (*O. hemionus*) are both found on NEPE and BIHO sites.

Identification and Biology

Deer are even_toed ungulates that weighing up to 400 pounds, depending on species and location. Mule deer have large "mule" ears and a black-tipped or black tail on top. White-tailed deer have a broad, all white tail below that is held up as a flag while running. Males of both species begin to produce antlers during late spring which are fully formed by late fall and shed in mid_winter.

Deer prefer forest ecotones and readily utilize agricultural areas. They are most active in early mornings and late evenings. Deer have home ranges of several hundred acres, but this varies with season, sex, and quality of habitat.

Deer browse mainly on leaves, stems, and buds of woody plants. Forbs are favored in season, as well as fruits and nuts.

Breeding takes place in fall and early winter, with peak activity in about November. Mature females will give birth to 1-2 Fawns, generally during May and June.

Occurrence in the park

Deer are common native species at all park sites.

Potential Damage and Health Concerns

Deer are attracted to developed areas where they may scatter garbage, browse on ornamental shrubs, and cause general nuisances. Deer also pose potential safety hazards to visitors who approach too closely while taking photographs or attempting to feed them. A number of diseases common to humans (i.e. Lyme disease and, very rarely, rabies) and livestock are carried by deer and they may become aggressive towards humans during rut or in search of food.

Monitoring and Thresholds

Deer counts at night with spot lights are the most successful monitoring technique. This will allow a count of sex, age, and total population. Track counting is another method, but this only gives information on areas of use, and not population numbers, age, size, or sex.

Frequent or costly damage to ornamental plants or other cultural/natural resources, threats of human injury, or noticeable deer found around visitor use areas will be the action threshold for deer control.

Non_chemical Management

Deer are protected year_round in all states, except during legal harvest in hunting seasons. In cases of severe or persistent damage, states may issue special depredation permits to allow deer to be taken at times other than the legal hunting season. Regulations vary on the disposal of dead carcasses. Control of deer damage can be a difficult social, political, biological, and logistical problem; planning should always involve state wildlife agencies.

Fencing is one of the most effective long-term methods for deer exclusion. Electric and woven wire fencing is expensive and should be 8 feet high, topped with barbed wire. Electric fences should be 6 strands at a spacing of 10 inches with the bottom strand 8 inches above the ground. Another method of fencing is to angle the fencing outward so the overall height is shorter.

Individual trees or shrubs can be enclosed in hardware cloth or chicken wire. Seedlings can be protected by Vexar seedling protectors.

Scare devices, repellents, live_trapping, and shooting are other methods used in deer control. Scare devices are effective if actions are taken at the first indication of a deer problem, before behavioral patterns become established. Once feeding patterns and familiarity become established, these methods are rarely effective. Also, deer become acclimated to scare tactics.

Clover trap, dropnets, or immobilizing drugs are also effective ways to move small numbers of animals. These methods are labor intensive and costly and must be coordinated with state Fish and Wildlife agencies. Reduction measures must reduce a population by approximately 60% to effectively control depredation problems. Also, transplanted animals have been known to return to traditional areas from distances of more than 20 miles.

Chemical Control

There are no chemical toxicants registered for deer, however, the following repellents may be used on ornamental plants to deter browsing:

Approved Chemical Alternatives at NEPE:

None

Other chemical alternatives that must have prior approval include:

Thiram (Arasan) - taste repellent, aerosol spray; one application reportedly lasts 6_months;
Ziram, a fungicide ordinarily used for plant diseases;
BGR (Big Game Repellent, Weyerhaeuser Co., registered by McGlaughlin, Gormley, and King Co., Minneapolis, MN.) Cooperatively developed by the US Fish and Wildlife Service, made from fermented eggs;
Repel (Leffingwell Chemical, Brea, California) contains paradichlorobenzene;
Hinder, ammonium soaps or higher fatty acids, said to be effective for 5 to 7 days when sprinkled on plants. (20 percent solution of egg mixed with water is reported to be just as effective as some commercial repellents);
Coyote urine and BGR tested by Colorado State University found to be the best dilute repellents. Chicken egg solutions, Hinder, and thiram were intermediate in effectiveness.
Gustatory repellents which deter deer because of bitter taste should be applied to trees and shrubs during dormant periods; new growth appearing after treatment is unprotected. Repellents applied near plants repel deer by odor but are less effective than contact repellents.

Resources

Materials Available

No materials available.

Technical Experts

Contact the local fish and wildlife and/or County Extension Agent for the area.

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FLEAS

Common Name

Although there are over 250 species of fleas described in North America, only a few are commonly encountered by humans with enough frequency to be considered pests. These include the cat flea (*Ctenocephalides felis*), the dog flea (*C. canis*), the human flea (*Pulex irritans*), and the oriental rat flea (*Xenopsylla cheopis*). Other species, such as the rabbit flea (*Cediopsylla symplex*), the mouse flea (*Ctenopsyllus segnis*), the ground squirrel flea (*Diamanus montanus)*, and (*Oropsylla hirsuta*), a flea that feeds on prairie dogs, may achieve pest status when their host mammals nest in or near structures or the fleas attack hunters and hikers. Some, such as the northern rat flea, ground squirrel flea, and *Oropsylla hirsuta* are important vectors of sylvatic plague, bubonic plague, and murine typhus.

Identification and Biology of Fleas

This document will deal with the four most commonly encountered flea species mentioned above: the cat flea, the dog flea, the human flea, and the oriental rat flea. These fleas are found throughout the United States and are most likely to be encountered in mammal and bird nests or in pet bedding. Adult fleas are ectoparasites of their hosts, but unlike many other ectoparasites they do not spend the majority of their life cycle on their host.

Females deposit eggs in groups of 1 to 18 on the host after a blood meal. Some species, such as the cat flea, can deposit up to 25 eggs per day and over 1000 in a lifetime. Eggs soon drop off or are brushed off. Due to their spherical or oval shape, they roll into cracks and crevices on the floor or in or near nests and bedding. Eggs are whitish and 1/32" in diameter. Eggs hatch in 2 to 21 days.

Larvae are approximately 1/4" when first hatched, white, and have fine hairs. They lack legs or eyes but possess biting mouthparts. Most species feed on dried blood from the host (in the form of adult flea feces) or organic debris present in cracks and crevices. They also feed on cast larval skins. Depending on the availability of food, relative humidity, and other environmental factors, larvae pass through three stages (instars) in one week to several months. Optimal temperatures for larval development are 65 to 80^{o}F . Larvae need a relative humidity of at least 50%. It is important to realize that even if the relative humidity of the ambient air is not this high, it could be much higher in the microhabitat of a burrow or den. Larvae can also survive short exposures to below freezing temperatures. Larvae pupate within cocoons spun from silk and may be covered with debris.

The pupal stage usually lasts approximately one week. The newly emerged adult may remain in the cocoon for some time; under adverse conditions, the adult may spend up to a year in the cocoon. Emergence occurs in response to pressure applied to the cocoon or detection of host warmth, vibrations, or carbon dioxide in the host's breath.

Adult fleas are small, brownish insects flattened from side to side, without wings but with powerful jumping legs. Adults can live for several years and go without feeding for months at a time under extreme conditions. Fleas can remain in a structure long after the host mammals have been removed. Depending on the species and environmental conditions, adults can breed from two weeks to two years after emerging. Adults feed on blood, and females deposit eggs only after a blood meal. Most species remain on the host only long enough to feed. Nearly all species have host preferences but are not restricted to any one host species. This trait is responsible for the transmission of several diseases (e.g. plague or murine typhus) from one host species to another. Adults prefer warm humid places and will leave a host if it dies.

Outdoors, fleas are most abundant during humid, rainy summers and are more common outside in the southern United States than in the north. Indoors, warmth and high relative humidities are conducive to large populations. The sudden appearance of large numbers of adult fleas in mid-summer and fall ("flea seasons") is due in large part to the onset of higher humidities and temperatures which permit larval development to accelerate. Larvae may undergo arrested development in less than favorable conditions.

Occurrence in the Park

Fleas can occur in any area of the park where suitable hosts are present.

Potential Damage and Health Concerns

Flea bites vary in effect from short-lived itching welts to an overall rash to symptoms which may last over a year, depending on the sensitivity of the victim. Young children are more sensitive than older persons. Commonly, a small red spot appears where the skin has been pierced. Little swelling ensues, but the spot is accompanied by a red halo of irritated skin which usually lasts for several hours to a day.

Fleas are vectors of several diseases important to human health including plague, murine typhus, and tularemia. The oriental rat flea is the most important plague vector from rodents (primarily rats) to humans, but at least 30 other flea species can transmit the disease, including the northern rat flea, dog flea, cat flea, and the human flea. Plague (in the sylvatic form) is endemic in the western United States in small rodents such as chipmunks, ground squirrels, and prairie dogs.

Nearly all known cases of plague in humans in the United States since 1925 have been associated with wild rodents (mostly from the Rocky Mountain states) and their fleas. The greatest threat to humans exist when domestic rats are exposed to infection from wild rodents in areas adjacent to human communities.

Murine typhus is a mild form of epidemic typhus that is usually spread by the human louse. The Norway rat population is the main reservoir of the disease. The disease is most common in the southwestern and Gulf states. The disease is commonly spread from rat to rat, and from rat to human by the oriental and northern rat fleas. It has also been transmitted by cat fleas from infected feral cats.

Fleas are also vectors of tularemia, a disease related to plague. The natural reservoirs of tularemia are cottontail rabbits in the East, and jack rabbits in the West. Most cases reported are by hunters.

Fleas can also be intermediate hosts of several species of tapeworm including species which parasitize humans, dogs, and cats.

Monitoring and Thresholds

Fleas can be monitored in several ways. The simplest is to count and collect fleas landing or crawling on an observer's lower legs for one minute. In making surveys, trousers should be tucked into white socks to prevent bites and make collecting easier (socks can be put on over shoes). Light-colored trousers are preferred to provide greater contrast and facilitate counting and collection. A variation on the above is to wrap fly paper (sticky side out) around the lower legs and count fleas adhering after a predetermined interval.

Fleas may also be combed off animals for an index of animal infestation. Do this over a white surface so fleas can be easily observed.

Pet bedding should be periodically checked for flea eggs and dried-blood feces (frass) of adult fleas. This has been described as "salt and pepper" because it looks like small flecks of black and white debris. The frass is generally cylindrical, twisted, and about 1/16" long. It is dark in color. Larvae and pupae can be found at the edge of pet bedding or animal nests.

Five or more fleas on the legs of observers in less than one minute is the Action Threshold.

Flea populations in animal burrows or dens can be sampled by using a flannel cloth that is run through the burrow on the end of a plumber's snake. The number of fleas on the cloth is then counted. See Barnes et al. (1972) for more detail.

Non-chemical Management

Flea management is best done via management of the host animal's habitat. Since fleas must spend part of their life cycle on their host, the chances of encountering fleas in areas of the host's habitat where it spends most of its time (e.g., its den or nest) are much greater than in a general area, such as a field or barn in which the host may or may not be found at a given time. One author has suggested that most fleas spend more time in the host nest or burrow than on the host itself. This is the emphasis that will be placed on flea management strategies in this park.

In outdoor settings, the emphasis should be on spot treatment of nests with an insecticide. Exclusion of the host animal from an area may be desirable as well, but the feasibility of this strategy will vary with the animal and the location of its nest. In the case of domestic animals, sanitation should be the focus of a flea management program. Regular cleaning of bedding and other areas where the animal spends the majority of its time should reduce flea populations to non-irritating levels.

In areas where plague is endemic, efforts should be made to keep humans and fleas (and their wildlife hosts) separate. Outdoor activities should be restricted during an outbreak when fleas seek other hosts. Ground squirrel burrows can be dusted with insecticide. Check with Public Health Service officials if your area is affected.

In most other cases, fleas are considered pests due to the nuisance caused by their bites. In these situations, management decisions should be made on a case-by- case basis.

Fleas require warm-blooded hosts for development and for egg maturation. Elimination of suitable habitat for wild rodents and other animals near structures will often reduce flea population levels. Screened vents prevent animals from resting inside or underneath structures. Eliminating vegetation close to structures and raising woodpiles off the ground reduces rodent harborage.

Indoors, wash or vacuum all pet bedding and sleeping areas on a regular basis. Cracks and crevices should be vacuumed and sealed, especially the area between the baseboard and floor. Dispose of vacuum cleaner bags to prevent reinfestation. Pets should be washed regularly and treated with insecticides if necessary. The ultrasonic collar is sometimes for the control of fleas on domestic animals. A recent study showed that ultrasound devices are ineffective.

A new technology in the management of fleas is the use of insect growth regulators (IGRs). These substances are similar to chemicals produced by the flea to regulate the shedding of its skin during molting. They work by interfering with the molting process, thus preventing the immature flea from developing into an adult. This method of control is a long-term process, since it will only kill larvae as they molt. A recent study using pyriproxyfen (sold as Nylar), an insect growth regulator reported to be effective against several insects, examined its effectiveness against the cat flea. One problem with insect growth regulators is that they break down when exposed to light, limiting their outdoor use. In this study, Nylar was determined to be stable when exposed to light. It was found to persist in home yards for three weeks after application and to prevent development of 90% of the fleas in treated areas. Another effective IGR for flea management indoors is methoprene (trade name Precor). It is important to combine the use of a material such as this with observations of the infested animal's movement so that only areas where it spends the majority of its time are treated.

Fleas are preyed upon by ants and beetles that feed on larvae in the host's nest.

Chemical Control

Insecticides are also part of a flea management program. These are applied to areas where fleas are most likely to breed, including animal bedding, cracks in floors, and baseboards. Many veterinarians also recommend the use of indoor foggers to apply pesticides to rooms where domestic animals spend the bulk of their time. Flea collars are not considered to be effective. When insecticides are used, it should be in conjunction with sanitation. One difficulty with the use of insecticides as part of a flea management program is the ability of the adult flea to remain in its cocoon as a preemerged adult. This means that the adult flea can remain in the cocoon in which it pupates until it encounters a suitable host. Insecticides have been found to be ineffective against these preemerged adults.

This highlights the importance of sanitation as the key element in a flea management program.

Approved Chemical Alternatives at NEPE:

Flea powder, commercial;
Hypochlorite (household bleach) sanitizer;
Personal insect repellents containing DEET and/or permethrin.
Pyrethrum contact sprays;
Silica aerogel and sillca gel.

Other chemical alternatives that must have prior approval include:

Carbaryl dust (sevin) dusting of burrow entrances in the event of notification by CDC of human health hazard due to fleas;
Fenoxycarb (IGR) for fleas;
Methoprene (IGR) for fleas.

Resources

Materials Available

Materials available include common sense items such as doors, window screens, and basic sanitation procedures.

Technical Experts

NPS-WASO IPM Coordinator, Columbia Cascades Cluster IPM Coordinator, and/or the County Extension Agent for the area.

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NORTHERN FLICKER

Common Name

Northern flickers (*Colaptes auratus*) are common and well known woodpeckers found throughout most of North America.

Identification and Biology

Northern flickers are medium sized, with fairly long, pointed bills. Their upper parts are dark-barred brown with a plain white rump, and underparts are boldly spotted on a pale background. There is a prominent black crescent on the breast. The head pattern and the feather shaft and underwing colors are distinctive in the west, with the face gray, the crown brown with no red on nape, and the shafts/underwing are salmon-pink. The male has a red moustache.

Flickers are birds of open areas and forest edge, but may frequent a broad range of habitats, provided access to open ground is available. Flickers can be found in open forests, recent clearcuts (2-6 years), burnt areas, farmland, pastures, and residential areas. Flickers are most active during the early morning and evening hours, but may be seen at all times of the day. They appear to mate for life, and show aggression only to members of the same sex.

The staple food (about 75%) of this omnivorous species is ants and ant broods. They will also eat termites, caterpillars, beetles and their larvae, wasps, crickets and grasshoppers, aphids, and spiders. Fruits and berries (i.e., dogwood, poison ivy, sumac, hackberry, cherries) are important components of their diet, as well as seeds, acorns, and other kinds of nut kernels.

Flickers breed from February to July. Nests are usually excavated in dead trees or in dead parts of live trees, and most are located close to the distal end of a stub. Because they have a low inclination to excavate, many other, often peculiar, nest sites have been recorded.

Occurrence in park

Flickers are native and can be found in almost all areas of the park.

Potential Damage and Human Health Concerns

Flickers damage buildings and structures by pecking holes into wood in search of nesting cavities and food.

Accumulations of debris and feces can increase potential for associated ectoparasites to enter buildings.

Monitoring and Thresholds

The action threshold for flicker control will be frequent or costly damage to buildings/structures or other cultural or natural resources.

Inspection and monitoring techniques for flickers are similar, involving inspection of structure exteriors for scratch, peck marks or holes. During the breeding season, these inspections must be made weekly, due to the speed of the birds' potential damage. Periodic monitoring of flicker activity (early morning/evening census, frequent exterior structure inspections) will provide information on the effectiveness of previous treatments.

Evaluation of treatments supply essential information for adjusting Action Threshold values, developing more effective management strategies, and demonstrating any apparent needs for new control methods or chemicals.

Non_chemical Management

Flickers are protected year_round in all states. In cases of severe or persistent damage, the US Fish and Wildlife Service may issue special depredation permits to allow flickers to be taken. The disposal of dead carcasses must be according to specified rules. A yearly summary of actions is required for compliance with the permit. Flicker damage control can be a difficult problem.

It may be necessary to treat wood structures for infestations of insects before successfully eliminating flicker problems. This may be difficult, since some research has shown that flickers will peck on wood structures that are not infested. In some instances it believed that electricity traveling through wiring attracts flickers and initiates pecking actions.

Where possible, place flicker nesting boxes. Plans for these are in the NEPE Resource Management Office. Flickers prefer to nest in previously excavated cavities and will frequently use bird houses. Scare devices, netting, and live-trapping are other methods used in flicker control. These techniques have minimal success since habituation seems to lessen the impact on persistent birds.

Chemical Control

Benzyldiethyl methyl ammonium saccharide (Ro-Pel) may be an alternative in repelling woodpeckers in residential areas. This is used as a spray on the outer surfaces of wood to deter flickers from pecking.

Approved Chemical Alternatives at NEPE:

None

Other chemical alternatives that must have prior approval include:

Benzyldiethyl methyl ammonium saccharide (Ro-Pel) sprayed on outer wood surfaces to deter flickers from pecking.

Resources

Materials Available

No materials available.

Technical Experts

Contact the local fish and wildlife and/or County Extension Agent for the area.

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POISON HEMLOCK

Common Name

Poison Hemlock (*Conium maculatum*), is native to Eurasia and was introduced into the United States by way of Europe.

Identification and Biology

Poison hemlock is a member of the parsnip or wild carrot family. It is a biennial, and reproduces entirely by seed. Seedlings have one pair of smooth, spoon-shaped, dark green cotyledons or "seed leaves". Subsequent leaves are pale green and finely divided. The plant remains in a vegetative form for the first year and produces a large rosette of leaves. In the spring of the second year the plant will produce a tall, erect stalk, which holds the seedhead. The stalk is from 4 to 12 feet in height. Poison hemlock has a long, white taproot that may branch. The stem is strong, smooth and mottled with purple spots. The leaves are toothed, divided into threes, and deeply cut. Each flower develops into a green, deeply ridged fruit that contains several seeds which turn grayish-brown at maturity.

The plant is found throughout Idaho along roadsides, waterways, and cultivated fields in waste areas.

Occurrence in Park

Poison hemlock is found at Spalding, White Bird Battlefield, and East Kamiah.

Potential Damage and Health Concerns

Poison hemlock is an persistent weed of pastures, waterways, and roadsides. It presents a challenge to the management of native vegetation and the maintenance of cultural scenes.

All parts of the plant are poisonous to people and livestock. The plant resembles parsnips, parsley, anise, and the wild carrot to which it is related. Poison hemlock contains five volatile alkaloids which are chemically related to nicotine, and these toxins were used in ancient times as a means of putting condemned men to death. Also, Indians mixed crushed seeds with decomposed deer liver to poison war arrows. It is related to water hemlock (*Cicuta douglasii*), one of the most poisonous plants known to man.

Monitoring and Thresholds

Inspection and monitoring for poison hemlock will be as follows. On a monthly basis, each site will be traversed to record growth and distribution. The locations, relative number or percent of area covered on the ground, and growth stages will be recorded. In addition, all locations where the plants are expanding will be noted.
Occurrences of this weed within the park will be the Action Threshold.

Non-chemical Management

Effective control involves a combination of mechanical control, herbicide treatments, biological control agents, and establishment of competitive native vegetation.

Plants can be mowed or cut after they have developed seed stalks. A single cutting will not usually kill plants. Repeated cutting will reduce its competitive ability and prevent or reduce subsequent seed production so that existing grass and vegetation can eventually replace and out compete poison hemlock. Frequent reinvasion of poison hemlock occurs after cutting because plants send up new seed stalks. Seedlings need to be controlled by biological and/or chemical means.

Establishment of perennial grasses after herbicide treatment is necessary to prevent reinvasion. Grasses with early growth, strong seedling vigor, and a large root system with good lateral spread have the greatest potential to compete successfully with poison hemlock. Most authors recommend initially controlling poison hemlock with

herbicides (2,4-D) while grasses establish.

A biological control agent available in the battle against poison hemlock is *Agonopterix alstroemeriana,* a leaf, bud, and flower eating moth.

Prescribed fire may be used to control poison hemlock seed production if plants are burned in the early flowering stage before seed matures.

Chemical Control

Poison hemlock can be controlled by applying 1 to 2 pounds per acre of 2,4-D during the seedling year and/or before the seed stalk begins to develop. Repeated applications may be necessary. Addition of a good wetting agent will aid in effectiveness.

Approved Chemical Alternatives at NEPE:

Glyphosate (Rodeo, Roundup)
Class 40 phenoxyherbicide
2,4-D (used in pre-treatment of areas in revegetation efforts).

Resources

Materials Available

Materials available include hand tools (eg. shovels, rakes, pruners, etc.), gloves, and approved chemical treatments.

Technical Experts

NPS-WASO IPM Coordinator, Columbia Cascades Cluster IPM Coordinator, and/or the County Extension Agent for the area.

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KNAPWEEDS

Common Name

Spotted knapweed (*Centaurea maculosa*), native to Eurasia, was introduced into western North America in the late 1800's, possibly with alfalfa (*Medicago sativa*) seeds imported from Turkey. It is naturalized across most of the United States and southern Canada with the exception of the southeastern United States. High densities are concentrated in the western rangelands and foothills of British Columbia, Washington, Montana, and Idaho.

Other knapweeds of concern, but have not been reported on NEPE and BIHO lands, include Diffuse knapweed (*Centaurea diffusa*), Russian knapweed (*Acroptilon repens*), and Meadow knapweed (*Centaurea pratense*).

Identification and Biology

Spotted knapweed is one of the most important rangeland weeds in western North America. Approximately 7.04 million acres (2.85 million ha) were infested in the western United States by the late 1980's. Spotted knapweed rapidly invades overgrazed rangeland and other disturbed sites, and is capable of establishing in undisturbed communities as well. Grass cover declines as spotted knapweed cover increases because of competition with spotted knapweed and overgrazing of the remaining grass. The decline in grass cover results in a net loss of forage for wildlife and livestock. The ability of spotted knapweed to invade undisturbed communities is a concern to managers of natural areas in the western United States.

Spotted knapweed occurs in disturbed grasslands, shrublands, and open forests. In the western United States, it appears to be best adapted to rangelands, but will invade areas of Douglas fir (*Pseudotsuga menziesii*) and Ponderosa (*Pinus ponderosa*) habitat type series. Spotted knapweed readily establishes on disturbed sites but does not offer as much erosion control as grasses.

Domestic sheep readily graze rosettes and flowerheads. Cattle have been observed browsing foliage in spring and early summer. Rodents eat spotted knapweed seeds. Spotted knapweed is considered poor cover for upland gamebirds, small nongame birds, and small mammals in Montana. Spotted knapweed provides nectar for honeybees.

Spotted knapweed is an introduced, perennial forb with one to several erect, freely branched stems growing 1 to 3 feet (0.3_1 m) tall. An individual plant has numerous flowerheads. Achenes are 0.10 to 0.14 inch (0.25_0.35 cm) long. A 0.12_inch (0.3 cm) pappus is usually attached. The average spotted knapweed lifespan is 3 to 5 years, but individual plants can live at least 9 years. In older plants, lateral shoots arise from beneath the soil surface and form multiple rosettes. Spotted knapweed has a stout taproot.

Spotted knapweed reproduces entirely by seed and is a prolific seed producer. On an infested site in Idaho, spotted knapweed produced an average of 1,020 seeds per square foot (11,300/sq m) in a dry year and 2,660 seeds per square foot (29,600/sq m) in a wet year. Individual plants on dry rangeland produce an average of 436 seeds. Because of high seed viability and sheer number, only 0.1 percent of seeds produced are required to maintain an existing spotted knapweed population. Spotted knapweed seeds are dispersed up to 3 feet (1 m) from the parent plant by a flicking action. The dehydration and opening of bracts results in seeds being quickly expelled if the stem moves. Seed is also dispersed by animals, in hay, and by vehicles.

Spotted knapweed seeds exhibit three germination behaviors: dormant light_sensitive, dormant light_insensitive, and nondormant. A cool, moist 30_ to 60_day stratification enhances germination. Storage of seeds at 5 degrees Fahrenheit (_15 deg C) for 60 days removes the stratification requirement. Although spotted knapweed seeds germinate under a broad range of conditions, germination immediately after maturity requires optimal conditions: 59 to 77 degrees Fahrenheit (15_25 deg C) temperature and soil moisture near field capacity. Spears and others determined that spotted knapweed seeds require greater than 55 percent initial soil moisture to initiate emergence, with 65 to 70 percent being optimal. Depth of seed burial affects germination and emergence. In one study, spotted knapweed seeds emerged from a depth of 1.5 inches (3.8 cm), but not 2 inches (5.1 cm). Lindquist and others

reported that percent germination is inversely related to depth of burial. Spotted knapweed seeds at the soil surface had 95 percent germination, seeds buried only 0.25 inch (0.6 cm) deep had 40 percent germination, and seeds buried 2 inches (5.1 cm) deep had about 10 percent germination.

Dormant seeds form a seedbank. On a site where spotted knapweed seed production was prevented for 7 years, spotted knapweed soil seed reserve declined by 95 percent. However, approximately 160,000 viable spotted knapweed seeds per acre (400,000/ha) remained after 7 years. After 8 years burial at one site, spotted knapweed seed viability averaged 28 percent. Near Spokane, Washington, seedlings grown in a common garden from seeds collected in northwestern Washington and northern Idaho emerged in April with a high rate of survival. Most flowering occurred the following growing season. Those seedlings emerging after May 15 had very low survival rates and almost none flowered the following growing season. Shade had no effect on emergence but reduced the survival of rosettes.

In Montana, high densities of spotted knapweed occur under the following conditions: 4,000 to 6,000 feet (1,200_1,800 m) elevation, 12 to 30 inches (30_76 cm) mean annual precipitation, 50 to 120 frost_free days, 16 to 25 inches (40_64 cm) potential evapotranspiration, and 80 to 86 degrees Fahrenheit (27_30 deg C) mean maximum July temperature.

Spotted knapweed frequently occurs on gravelly, coarse_textured soils. Most soil types in Montana support spotted knapweed. According to some authors, any soil type in the dry British Columbia interior with a disturbed A horizon is subject to spotted knapweed invasion.

Spotted knapweed grows on well_drained sites. It occupies slightly moister sites than diffuse knapweed but does not do well in irrigated pastures where soil saturation is common. Spotted knapweed is uncommon in habitat types moister than the Douglas_fir series or drier than the ponderosa pine series.

Spotted knapweed is not tolerant of shade. Spotted knapweed is an early successional species. It rapidly colonizes disturbed sites such as roadsides and overgrazed rangelands. It forms near monocultures in some areas of western North America. Spotted knapweed populations expanded 7 to 14 feet in 4 years into undisturbed rough fescue communities in western Montana. The sites had been ungrazed by livestock for 30 to 40 years; bare soil averaged 2.7 percent of area cover.

Spotted knapweed seeds germinate in either spring or fall. Seedlings develop into and remain rosettes for at least one growing season while root growth occurs. Spotted knapweed usually bolts for the first time in May of its second growing season and flowers in July and August. Individual flowers bloom for 2 to 6 days. Seeds are shed immediately.

Spotted knapweed shows moderate increases after fire. Established plants may regrow and/or buried seed may germinate after fire. In the Lick Creek drainage of the Bitterroot National Forest, Montana, shelterwood cuts in dry Douglas_fir and ponderosa pine communities showed increases in spotted knapweed after prescribed spring fires on both wet and dry duff. On the wet burn site, spotted knapweed prefire cover was 0.5 percent and postfire cover was 1.0 percent. On the dry burn site, spotted knapweed prefire cover was 1.9 percent and postfire cover was 3.6 percent.

Prescribed burning alone is probably not effective for controlling spotted knapweed and may cause increases, but prescribed burning may be useful in conjunction with herbicides. In Montana, tests were conducted with the possibility that burning may reduce herbicide interception by old spotted knapweed stems and may increase seed germination, increasing the effectiveness of subsequent herbicide treatment. However, burning did not increase herbicide effectiveness. The April fire was followed by an unusually dry period so spotted knapweed did not germinate prior to the May herbicide treatment. Using prescribed fire to reduce big sagebrush (Artemisia tridentata) in semiarid grasslands may expose sites to invasion by spotted knapweed.

Occurrence in the Park

Spotted knapweed is found on the Idaho sites and at Big Hole National Battlefield.

Potential Damage and Health Concerns

Knapweeds are important rangeland and pasture weeds in North America. They rapidly invade overgrazed rangeland and other disturbed sites. These invasive weeds do not present any human health concerns. Knapweeds can drastically alter the historic and cultural scene of areas.

Monitoring and Thresholds

Knapweeds are relatively conspicuous weeds and in most cases periodic visual inspections should be sufficient to monitor thistle populations. The permanent plot photograph technique is a good way to monitor thistle populations after they have become established and while they are being controlled. A representative section of the field is marked off. Take a series of photographs of the sample plot showing the density of thistles and condition. Include in the photo an object of known size (person or measuring stick) to indicate thistle size. Also include in the frame a sheet of paper with the date in bold letters. All photos should be taken from the same location with the camera pointed in the same direction and with lenses of equal coverage. This method is especially useful in monitoring the effects of control measures over the course of several seasons. Knapweeds in each photo can be counted and mapped and notes made on their condition (height, flowering, etc.). Monitor on a regular basis (monthly). Keep careful records, note when treatments take place, or when biological controls are introduced (naturally or artificially). Study of records, over time, will show population trends and indicate whether or not control strategies are successful.

Occurrence of knapweeds will be the Action Threshold.

Non-chemical Management

Surveys for possible European biological control agents began in 1961. In 1973, a European seed_head fly, Urophora affinis, was released in the United States. Subsequently, six more seed_feeding insects and four rosette and root_feeding insects have been released. Insects, release dates, and establishment data are described. Biological control agents have not yet been effective at reducing spotted knapweed densities, but some have been effective at reducing seed production. In cage studies, two introduced flies, U. affinis and U. quadrifasciata, reduced spotted knapweed seed production by 36 percent the first year and by 41 percent the second year. These same two flies combined to reduce seed production by 80 to 90 percent at a site in British Columbia. Black leaf blight fungus, *Alternaria alternata*, is highly toxic to spotted knapweed. The phytotoxin maculosin has been isolated from *A. alternata* and research on its possible use in spotted knapweed control is ongoing. In order to slow the invasion of spotted knapweed, continued distribution and propagation of introduced insects should be combined with other control programs (altered grazing regimes, seeding of grasses, and herbicide treatments) which encourage grass growth. In a clipping experiment, spotted knapweed biomass was substantially affected only if plants were defoliated at monthly intervals throughout the growing season.

Competition from grass reduces spotted knapweed survival, biomass, and reproduction more substantially than does herbivory alone. Under competition from meadow fescue (*Festuca pratensis*), spotted knapweed survival, shoot number, and biomass per area decreased with increasing numbers of the root_feeding insect, *Agapeta zoegama*. Graminoids generally increase after spotted knapweed control. Native grasses perform best on the dry rocky soils common to spotted knapweed infestations.

Fertilizer may contribute to an increase in spotted knapweed. Cnicin, a phytotoxin present in spotted knapweed foliage and roots, may be allelopathic. Spotted knapweed foliage extracts retarded germination and shoot and root growth of lettuce and barley. Cnicin is especially effective at retarding root growth of competing plants.

Chemical Control

While some herbicides are effective against spotted knapweed, herbicide effectiveness is limited due to size of infestations, the rapidity of reinvasion, high costs, and buried seed longevity. The most effective herbicide for long_term spotted knapweed control is picloram, which provides complete control for 3 to 4 years. Dicamba gives 2

to 3 years of control, and 2,4_D is effective for 1 year. Neither picloram or clopyralid significantly affected native forb density or diversity of palouse prairie in western Montana and gave at least 80 percent control of spotted knapweed. If the area of infestation is small, hand pulling and spot treatment with clopyralid (Transline) applied at 0.13-0.19 L/ha (0.66-1.0 pt/acre) or clopyralid + 1.12 kg/ha 2,4D (Curtail) provide control with little to no soil residual. This should be applied during the bolt or bud stage. For larger infestations, hand pulling may present manpower problems, but the application of clopyralid rate is the same. Clopyralid is a non-restricted use pesticide, but will still be used under the direction of a certified pesticide applicator.

Care must be taken to not reduce biological control agents with herbicides.

Approved Chemical Alternatives at NEPE:

Clopyralid;
Picloram;
2,4-D amine.

Other chemical alternatives that must have prior approval include:

None.

Resources

Materials Available

Materials available include hand tools (eg. shovels, rakes, pruners, etc.), gloves, and approved chemical treatments.

Technical Experts

NPS-WASO IPM Coordinator, Columbia Cascades Cluster IPM Coordinator, and/or the County Extension Agent for the area.

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MICE

Common Name

There are numerous species of native and introduced mice that occur in the United States. These are small, nocturnal mammals with high fecundity.

Identification and Biology

Deer mice (*Peromyscus maniculatus*) are the most common mouse likely to be encountered in NPS structures and serve as a good example of most rodents. Deer mice are the most widely distributed and abundant mammal in North America and thrive in almost every dry, land habitat from deserts to grassland and range over most of the United States.

These are small mice with large ears. They have white feet and bellies, and have a distinct color separation from the upper to lower portions of their bodies, going from brown to white. Their tails are also bi-colored and are as long as the head and body combined.

Deer mice nest together in family groups during the breeding season. Whenever a mate dies, another is quickly found. These mice do not hibernate, but they will enter short periods of torpor for short periods of time.

Deer mice will nest in any location that is secluded from the elements. Nests are made of any materials that will provide warmth and protection, such as twigs, leaves, grass, fur, feathers, and cloth.

Reproduction in deer mice can be constant and females may be continually pregnant from April through October. In warmer regions, especially in buildings, mice may reproduce year-round. Most rodents have high reproductive rates, which enables their populations to rebound quickly after pest control activities, predators, disease, or weather conditions have reduced their numbers.

The normal gestation period for mice is from 21 to 23 days, with 3 to 5 young being born. The young are weaned in about 2 to 3 weeks and become sexually mature at 7 to 8 weeks of age. Mice will typically have between 3 and 5 litters per year. High reproductive rates adapt rodents to rapid population growth and quick recovery when their numbers are reduced by pest control programs, predators, or adverse weather conditions.

Deer mice are primarily seed eaters, but will readily take a large variety of other food stuff. When food is abundant, mice will cache food near nesting sites. Elimination or reduction of food, water, or harborage stresses a population and threatens its existence.

All mice select territories that provide shelter, nesting, and secure lanes of travel. There is a high degree of home range size because of the distance that individuals will travel between nests and food. Population density is variable, with the highest rates during the summer. Average life spans are seldom more than 3 months during the summer. Large populations of mice can be seen during seasons when food and storage places are available. Populations consistently peak during the fall.

Mice are invariably found near all structures and will attempt to move indoors when cooler fall weather turns outdoor conditions harsh.

Almost all mammalian carnivores, raptors, and many snakes and amphibians prey upon mice.

Occurrence in the park

A variety of mice and other rodents occur within the park and may become nuisance and/or health related pests when they enter structures.

Potential Damage and Health Concerns

Mice may enter any structure that is not rodent proof and provides harborage where they store food. Food caches and/or dead rodents attract a variety of other pests. Rodents may also cause damage when attempting to reach these food caches. Rodents damage furniture, mattresses, clothing, papers, etc. They chew into food containers and the urine, feces, hair, etc. they deposit contaminates the area of deposition. Rodent feces attract other mice and pests. Digging near foundations of structures loosens soil, increases permeability and increases erosion of foundations and structural components.

Mice and other rodents can damage vegetation when they dig up seed or browse on plants, including ornamentals.

Many ectoparasites are found in association with mice. These include helminths, arthropods, fleas, tapeworms, pinworms, flukes, mites, and lice. Some diseases carried by mice include salmonellosis, leptospirosis, trichinosis, and typhoid. Deer mice are also vectors for sylvatic plague and tularemia, and tick_born rickettsioses (as Rocky Mountain spotted fever and Q_fever), but are resistant to these diseases. Many rodents, but mice in particular, are vectors of Hantavirus Pulmonary Syndrome (HPS), which is transmitted to humans through contact with mice nests and dried mice feces, urine, and body fluids.

Monitoring and Thresholds

Documentation of rodent infestation includes finding droppings, gnaw marks, shredded paper or caches of nesting material, or caches of food. Mice also emit a characteristic musky odor and are occasionally seen during the daytime.

Because of the dangers of Hantavirus, all persons engaged in inspections and monitoring for and who might come into contact with rodents or dry rodent debris should wear approved personal protective equipment and follow Centers for Disease Control guidelines (Appendix M) for personal safety.
Bi-weekly (or more frequent) monitoring is necessary in areas of rodent problems to maintain familiarity with structures and detect and document subtle signs such as droppings or urine stains, sounds, burrows and nests, seed caches, odors, runways, tracks and rub marks, or gnawing which may be presented. Maintain proper sanitation of all areas so sign such as feces or shredded materials can be detected. Use of a flashlight is recommended, even during the daytime.

Exterior inspections should identify and document all possible areas of rodent entry. Zones of rodent activity should be noted, such as, weeds, tall grass, debris, loosely covered garbage containers, vegetation touching or overhanging buildings, door sweeps, windows, pipes, etc. In addition to these, locate any source of food or water for rodents.

Periodically examine and document conditions in the same areas. Monitoring will also require the use of snap traps, sticky traps, or tracking boards to be placed throughout buildings in areas of potential rodent use. Tracking powder is also an effective monitoring device to determine the presence/absence of rodents in structures.

Constant monitoring will provide information on rodent occurrence and population fluctuations.

“Mice” is meant here to include a full array of smaller rodents which may include the genera Perognathus, Dipodomys, Peromyscus, Rheithrodontomys, Onychomys, and Sigmodon.

The Action Threshold for mice inside visitor centers, residences, or other occupied buildings will be the evidence of even a single rodent. There will be no use of rodenticides inside structures. Animals that die in inaccessible areas create odors and carcasses attract other pests, aggravating the problem.

Action Thresholds for mice in outdoor locations are:

- Mouse burrows in, under, or adjacent to 10% or more of the walls or foundations.

- Excessive mouse damage to any cultural resource at any time of the year.

Non_chemical Management

Rodent control necessitates implementation the processes of monitoring, sanitation, exclusion, and population reduction. The most effective of these is exclusion, but must be combined with good sanitation and monitoring.

All exterior openings larger than $^1/_4$- inch be sealed with $^1/_4$-inch (or smaller) mesh hardware cloth, metal flashing, or durable caulking. Hardware cloth or metal flashing should have the edges buried several inches below soil line to exclude rodents from foundations. After use, chimneys should be closed or covered with hardware cloth or covers. Screens on windows should be properly maintained and doors with properly fitted sweeps kept closed. Foodstuff, including pet food, should be stored in containers with tight fitting snap lids.

Again, cleaning of areas in and out of buildings will reduce harborage. Remove boxes, debris,, garbage, etc. and store materials off the floor on pallets or shelves. In cupboards or chests, turn drawers upside down so rodents cannot nest in them.

If trapping rodents indoors, mouse-sized traps are effective. Several traps should be set, even if only one rodent is suspected. Prepare the trap so minimal disturbance will release it. File any catch mechanisms so they are smooth and do not prevent proper release action. Use "chunky" peanut butter and lodge chunks of peanuts into the gripper of the bait plate so the rodent will have to gnaw on them to get them out. Check traps frequently and dispose of dead mouse by placing them in a zip lock plastic bag before placing them in the garbage. This will prevent odors and also attraction of other pests.

It may be necessary to vary the type of bait used. Alternatives include "chunky" peanut butter, cotton ball soaked in vanilla, and raisons (tied to the bait plate).

Chemical Control

There are a variety of poisons that are effective in the treatment of mice, however, poison baits are not recommended for use inside occupied structures by the NPS. Rodents will carry and store baits in other places where they may be found and consumed by other animals, including children and pets. Rodents may have to feed on baits for extended periods before toxic levels are reached, but they may become sick and repulsed to the bait before these levels are reached. If the rodents die, they will usually do so in spaces that are inaccessible and their carcasses will create odors and attract other pests. Most rodents will also eventually become resistant to toxic baits.

If outside control is required, cholecalciferol (Vitamin D3) may be a relatively safe rodenticide. Rodents are intolerant to Vitamin D as it causes vascular imbalances and excessive calcium deposition within their bodies.

Whenever rodenticides are used, place them in sealed bait boxes to protect non_target animals and humans. Bait boxes are available from pest control supply companies.

Approved Chemical Alternatives at NEPE:

None.

Other chemical alternatives that must have prior approval include:

Cholecalciferol (Vitamin D3).

Resources

Materials Available

Materials available include common sense items such as doors, window screens, and basic sanitation procedures.

Technical Experts

NPS-WASO IPM Coordinator, Columbia Cascades Cluster IPM Coordinator, and/or the County Extension Agent for the area.

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MID-SIZED MAMMALS

Common Names

These animals are grouped here for sake of convenience. They include the spotted skunk (*Spilogale putorius*), striped skunk (*Mephitis mephitis*), badgers (*Taxidea taxus*), and porcupine (*Erithizon dorsatum*).

Identification and Biology

Skunks and badgers are members of the weasel family. Skunks are small, mostly nocturnal, carnivorous mammals.

The striped skunk is about the size of a house cat and has prominent, lateral white stripes down otherwise jet black fur. This is skunk is commonly found in urban areas and near open spaces, washes, and canals. The spotted skunk is smaller and has white spots and short, broken white stripes on a black coat.

Skunks will dig holes in the ground for denning or in search of prey. During the winter, they do not hibernate, but will remain in dens during cold weather.

Skunks average from 9 to 37 per square mile, depending on habitat and resources. The average home range is from ½ to 1-½ square mile, but may increase to 4 to 5 miles during the breeding seasons. The life expectancy averages about 3 years.

Skunks are omnivorous and will feed on many items including mice, birds, eggs, insects, carrion, and some vegetative matter. They are especially attracted to garbage, pet food, and harborage of structures.

Skunks breed in early spring (February and March) and give birth in April or May, usually 2 to 5 young. The young stay with the mother until fall.

Predators of skunks are larger carnivores, hawks, and other large birds of prey.

Badgers have flat bodies that are wider than high. They have short, bowed legs that are used for powerful digging. They have shaggy fur that is grizzled gray to brown. They also have a white stripe from the shoulder to the nose, and white cheeks with black patches.

Badgers breed in late summer with from 2 to 5 young being born in March or April. They are primarily nocturnal when in close proximity to humans, but in other areas they are active by day.

Badgers prefer open plains, farmland, and sometimes forest edges where burrowing rodents are present.
The badger has few natural predators, because it is such a formidable adversary and it also exudes a skunk like musk.

Porcupines have a large chunky body, high arching back, and short legs. They have long guard hairs on the front of their body and quills on the rump and tail. Their feet have four toes on the front and five on the rear with long, curved claws.

Porcupines breed mainly in October and November. Single young are born in May or June. Porcupines are active throughout the year. They may den up in extremely cold weather. They are primarily nocturnal.

Preferred habitat are conifer forests and brush, and also deciduous woods.

Predators include fishers, coyotes, mountain lions, and bobcats.

Occurrence in the Park

Skunks, badgers, and porcupines do not present major problems in the park. Skunks are attracted to visitor use and

residence areas where they may disturb garbage cans, dig under structures, introduce fleas, and cause bad odors. Badgers are attracted to colonies of burrowing rodents such as ground squirrels. Porcupines can be found in all areas of the park, but especially in forested areas.

Potential Damage and Health Concerns

Skunks and badgers dig burrows under structures for denning. The dens have very disagreeable odors. Skunks and badgers sometimes dig holes in lawns to capture immature insect prey.

Skunks produce a nauseating, defensive odor from anal glands. This material can be accurately ejected for distances of 10 to 12 feet.

Skunk dens harbor ectoparasitic infestations (mostly fleas) which can be transmitted to humans. *Bavlisascaris columnaris*, a common roundworm found in skunks and closely related to *B. procvonis* (carried by raccoons), when transmitted to humans or wildlife can potentially cause central nervous system damage.

The striped skunk is a principal vector for rabies. Rabid skunks are nervous, active during the daytime, salivate excessively, and will usually show little fear of man.

Badgers cause extensive damage to any landscape by digging for burrowing rodents.

Porcupines can cause tremendous damage to vegetation, particularly trees in stripping large patches of bark from trunks and limbs. Porcupines also present hazards to other animals who venture too close and have quills driven forcefully into them. Body heat of the victim causes microscopic barblets on the end of the quills to expand and become more forcefully embedded.

Monitoring and Thresholds

Inspecting and monitoring are similar. Examine holes under structures for presence of characteristic foul odors. Place flour or talc tracking patches in front of holes and analyze footprints. Use a spotlight at night and count animals. Monitor rodent burrows to detect signs of badger digging. Inspect trees for signs of porcupine bark stripping or limb damage.

The Action Threshold for controlling skunks, badgers, or porcupines will be animals known to cause damage to structures or resources, or skunks acting as if they may be infected with rabies.

Non_chemical Management

Good exclusion is the best measure for keeping skunks from entrance to spaces beneath buildings. Repair and close opening along foundations. Screen ventilation holes and deck bottoms with hardware cloth mesh wire.

Dispose of garbage and food sources. Keep garbage cans clean and ensure that lids are tight-fitting.

Do not leave pet food or water out and store pet food in animal-proof containers. In gardens, pick up windfall or ripened fruits.

Remove debris from exterior of buildings which could serve as harborage or feeding areas.

Skunks and badgers are listed as furbearers in some states and are protected by game laws. Most states will also allow these to be taken by to control or alleviate animal caused damage. Check with the State Game and Fish Department before destroying or releasing skunks.

Skunks, badgers, and porcupines are usually live_captured in box traps. Leg_hold and Conibear traps are also effective if traps can be protected so as to not injure humans or other wildlife. Place traps in areas of greatest activity or near suspected entry points. Do not place traps under a building or deck (removal of the trap will most

often result in the trapper being sprayed by the skunk). Use raw whole egg, peanut butter, sardines, raw chicken, or pet food as bait in traps.

Skunks, badgers, and porcupines are usually nocturnal and using a floodlight at night will aid if shooting is determined to be the best measure of control.

The preferred measures for controlling skunks and other larger mammals is by livecapture cage trap. If necessary, humane destruction of trapped animals will be completed. If captured animals will be moved and released outside the park, arrangements will be first made with state wildlife agencies, U.S. Forest Service or other land owners/managers. Animals will be moved no less than 20 miles distant for release. Animals released will be marked by paint or other suitable means. Marked animals that return will be destroyed. Park personnel will take all possible precautions against disease transmission or personal injury during trapping, cage handling, transport, marking, and release.

Chemical Control

There are no registered toxicants for these mammals.

There are several repellants or fumigants that can be used for these mammals. These include:

Gas cartridges of sodium nitrate and charcoal release carbon monoxide and are registered den fumigants. These are reported to have a 70% success rate in killing small mammals enclosed in dens. These should not be used under buildings.

Mustard oil and capsaicin gustatory repellent.

Naphthalene or paradichlorobenzene commercial repellents for dens and are also not to be used near occupied structures.

Various pesticides are labeled for fleas which may originate in dens under structures.

Carbaryl dust (fleas)
Fenoxycarb (IGR) for fleas.
Flea powder, commercial.
Hypochlorite (household bleach) sanitizer.
Methoprene (IGR) for fleas.
Pyrethrum contact sprays for fleas.
Silica aerogel for fleas.
Silica gel with pyrenone for fleas.

Commercially marketed skunk odor deactivators are available from:

Bramton Co.
Drs. Foster and Smith Inc.
Fritsche, Dodge & Olcott Inc.
G.G. Bean Co.
J. Norris Corp
Neutron Industries
R.C.F. Developments Inc.

Approved Chemical Alternatives at NEPE:

Flea powder, commercial;
Hypochlorite (household bleach) sanitizer;
Pyrethrum contact sprays for fleas;
Silica aerogel and silica gel with pyrenone for fleas.

Other chemical alternatives that must have prior approval include:

Carbaryl dust (fleas);
Fenoxycarb (IGR) for fleas;
Methoprene (IGR) for fleas.

Resources

Materials Available

No materials available.

Technical Experts

Contact the local fish and wildlife and or County Extension Agent for the area.

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MISCELLANEOUS PLANTS

Distribution and Biology

Weeds are defined in a broad sense as plants growing in locations where they are not wanted, or as plants interfering with management objectives for a given site. Weeds can be plants of all categories, but fall into one of the following general growth categories:

Annuals are plants that complete their life cycle in less than one year. They reproduce by seed, grow fast, spread rapidly, persist because of abundant seed production, and are the easiest weeds to control.

Winter annuals germinate in late summer or fall, grow rapidly while weather permits, go into a partial resting phase during winter, resume growth in spring, and produce seeds which remain dormant until fall. Older plants die during early summer.

Summer annuals germinate in the spring, reach peak growth during hot weather, and die after seed production in the fall. Seeds lie dormant during the winter. These plants are usually shade intolerant.

Biennials require two seasons to complete a life cycle. They usually have a fleshy taproot and reproduce by seed.

Perennials live two or more years and reproduce by seed or vegetatively, which is usually plays a more significant role than by seed. Vegetative reproduction can be by either cuttings, creeping roots, stolons, or rhizomes. Native and exotic weeds, alike, are usually plants which are better adapted to survive in overly dry or overly wet, unshaded, disturbed, or otherwise hostile locations.

There are a large number of weeds which occur in the park. These include both native and introduced weeds. Weeds encroach on native species, cause damage to natural and cultural resources, and diminish aesthetics of areas. The policy of the National Park Service is to eliminate exotic plants. This, however, may not be feasible, either economically or logistically, for some weed problems. Efforts in this IPM program will be to concentrate efforts on weeds identified as high_profile by the NPS, states, county and local area weed coordinating groups, and park staff. This section highlights some of the weeds which have been identified as problems in the park and local areas.

Cheatgrass (*Bromus tectorum*). Cheatgrass, also known as downy brome, is an exotic annual or winter annual, invading grass that can grow to be 30 inches tall. The plants are covered with soft hairs in all stages of growth. Mature, hanging seedheads may be up to 6_inches long. Cheatgrass is widely distributed in this country and is common in roadsides, open fields, rangelands, and cultivated areas.

Cheatgrass seedlings produce roots at much colder soil temperatures (late winter and early spring) than many native perennial seedlings. This allows cheatgrass to outcompete other perennial grasses by taking up available moisture before the other plant species can get their roots into the soil profile. Cheatgrass matures rather quickly and dry plants become a fire hazard.

Cheatgrass reproduces by seed which usually germinates in the fall. When moisture is insufficient, germination may be delayed until winter or spring. Because of its biology, cheatgrass becomes a common weed in lawns.

Pavement weeds. Weeds found in sidewalk and roadway cracks may be of many different kinds but are in one of the following categories: winter annuals, summer annuals, perennials, or biennials. Some weeds found in pavement cracks reproduce solely by seed and others from rhizomes (underground stems) and/or from stem or root cuttings.

Common mullein (*Verbascum thapsus*). Common mullein is a stout, biennial standing from 2 to 6 feet tall. The plants are wooly with few branches that appear winged from leaf bases which extend down the stem. The flowers are light yellow, with five lobes, and are about an inch in diameter. The seedpods are two chambered and contain many seeds.

Mullein reproduces by seed which germinates throughout the growing season. Common mullein is an introduced

species from Eurasia that is found commonly in pastures, meadows, fence rows, and waste places, especially on gravelly soils.

Field bindweed (*Convolvulus arvensis*). Field bindweed or morning glory, is a perennial growing from a deep-seated taproot, which gives rise to numerous slender underground rhizomes or prostrate, twining stems. The leaves are arrow-shaped and alternate, about 1 to 2 inches long. The flowers are bell shaped, white to pink, may be as long as an inch in length, and borne on 1 inch stalks that rise from the axils of the leaves. The fruit is a two-celled capsule, less than ½ inch in diameter, and produces from two to four seeds. The seeds are rough, angled, and appear from brown to black.

Field bindweed was introduced from Europe. It reproduces from both rhizomes and seed and is difficult to eradicate. It is distributed in cultivated fields and waste places. It has a remarkable ability to adapt to different environmental conditions and may be found at elevations up to 10,000 feet. Because of a large, fleshy, deep-seated taproot, which may penetrate the soil to a depth of 10 feet, and which may repeatedly give rise to numerous long rhizomes, it is extremely difficult to eradicate.

Hoary cress (*Cardaria draba*). Hoary cress, also known as whitetop, is a perennial, growing from extensive, coarse, underground rhizomes. The stems, which are usually erect, but may spread, are 6 to 20 inches high, and may appear gray in color, because of a dense hair covering. The leaves may become 3 inches long and are oblong in shape with entire or coarsely toothed margins. The upper stem leaves are narrower, without petioles and are clasping. The flowers are numerous, small, white, and are produced in an umbrella-like inflorescence. As seed pods mature, the flowering shoot becomes elongated. The mature seed pod is inflated, heart-shaped, and a bit less than $^{1}/_{4}$ inch broad. A single reddish-brown seed, about $^{1}/_{8}$ inch long, is produced in each of the two cells of the pod.

Hoary cress was introduced from Europe and has become widespread in grain and other cultivated fields, meadows, waste places, and does particularly well in saline soils. It competes aggressively with other plants, forming dense, pure stands. It reproduces from both seed and rhizomes.

Chicory (*Cichorium intybus*). Chicory is a perennial which grows from 1 to 4 feet high and originates from a long, deep taproot. The leaves are alternate, rough, hairy, and the lower leaves are deeply cut and large. The flowering heads are about 1½ inches in diameter, with blue, or occasionally pink or white petals. The heads are open in the mornings and tend to close by midday.

Chicory was introduced from Eurasia and is a common weed of roadsides, fields, and other waste places. It reproduces from seed and is difficult to eradicate because of the exceptionally long taproot.

Black locust (*Pseudoacacia*), Sumac (*Rhus glabra*) and White poplar (*Populus alba*) are trees that grow from 15 to 75 feet in height. All three are naturalized natives, introduced from other parts of the United States. All reproduce from both seeds and/or rhizomes and removal is difficult because of prolific resprouting from stumps and roots.

Russian olive (*Elaeagnus angustifolia*) and Tamarix (*Tamarix pentandra*). These are exotic species introduced to the United States from the Mediterranean area. These are species that reproduce from seed, sink exceptionally deep tap roots and have the ability to dramatically alter habitat for their survival. Eradication is difficult because of prolific resprouting from stumps and roots.

Other introduced species, located on or in proximity to parklands, are barnyardgrass (*Echinochloa crus-galli*), green foxtail (*Setaria viridis*), quackgrass (*Agropyron repens*), jointed goatgrass (*Aegilops cylindrica*), wild oats (*Avena fatua*), common burdock (*Arctium minus*), curly dock (*Rumex cripsus*), flixweed (*Descurainia sophia*), prostrate knotweed (*Polygonum aviculare*), kochia (*Kochia scoparia*), common lambsquarters (*Chenopoduim album*), prickly lettuce (*Lactuca serriola*), common mallow (*Malva neglecta*), tumble mustard (*Sisymbrium altissimum*), puncturevine (*Tribulus terrestris*), western salsify (*Tragopogon dubius*), common teasel (*Dispacus sylvestris*), catchweed bedstraw (*Galium aparine*), common chickweed (*Stellaria media*), cornflower (*Centaurea cyanus*), cowcockle (*Vaccaria pyramidata*), blue mustard (*Chorispora tenella*), field pennycress (*Thlaspi arvense*), shepherdspurse (*Capsella bursa-pastoris*), and sowthistles (*Sonchus spp*).

Potential damage

Excessive or unusually vigorous weed growth damages archeological ruins, walkways, and roadways and reduces habitat for native wildlife, limits recreational use, presents an untidy appearance, causes human allergenic reactions, produces toxins or thorns causing safety hazards, provides fuels that support wildland fires, displaces native vegetation, and harbors rodent or pest populations which may support diseases or cause other problems.
The mere presence of weeds continually contributes to transport of a large number of seeds by wind, water, animals, people, equipment/ vehicles, etc. into other areas of the park. And, some weeds produce enormous numbers of seeds that can remain viable in the soil for decades before conditions encourage germination.

It is the policy of the National Park Service to eliminate all exotic weeds, if possible.

Occurrence in the park

Weeds occur widely throughout the park but become problems when they invade developed areas, lawns, or pavement cracks, invade natural areas, out_compete desirable plants, or otherwise interfere with management objectives for specific sites.

Monitoring and Thresholds

Inspection and monitoring techniques for weed species are similar. Periodically visit sites or walk along roadways and record weed growth and distribution. This is sometimes better accomplished during the blooming period (when plants are easier to recognize). Record locations, relative numbers or percent of ground covered, and growth stages for weeds. Also record data for any small, slowly expanding populations that, with only slight changes in environmental conditions (i.e. drought or fire), might rapidly increase.

If plants can not be identified in the park, place a representative sample of the seed head or flower, stem, leaves, and underground parts in a sealed plastic bag and send the sample to the local county cooperative extension service. A collection of properly identified weeds should be kept in the park herbarium.

To determine the average percent of weed cover in an area, randomly throw a 3_foot square grid onto a lawn or field area and count the numbers of squares showing weeds. Twenty or more of such samples should provide sufficient comparative data.

Inspection and monitoring techniques for weed species are similar. Periodically visit sites and record the distribution of plants and relative size/growth. Be sure to record data on small, slowly expanding populations because slight changes in environmental conditions (i.e. drought or fire) can allow weed populations to rapidly expand.

Regularly inspect paved surfaces and associated plantings for disturbances (cracks, exposed earth, accumulations of debris, dead cover plants) which could encourage or support weed growth.

To determine the average percent of weed cover for any given area, randomly throw out a 3_foot square grid having 100 sub_divisional units and count the numbers of squares showing weed plants. Twenty or more samples from various parts of the area should provide adequate data for comparative purposes.
If you can not identify specific weed plants, place a representative sample of the seed head or flower, stem, leaves, and underground parts in a sealed plastic bag and send the sample to the local county cooperative extension service. A collection of properly identified weeds should be kept in the park herbarium.

Take considerable efforts to identify any newly appearing weeds in the area to be assured they will not cause future management problems. Any new plants found in the area and recognized as Noxious Weeds by the state or county and which do not otherwise commonly occur in the area should be reported to the county extension agent or state weed control supervisor.

Action Thresholds will be reached whenever any weed species are observed to be causing actual or aesthetic damage to resources. Weeds described in this section are all vigorous competitors, rapidly spread and overtake desired

vegetation, or damage resources.

Non_chemical management

The effectiveness of non_chemical weed control depends on ingenuity, knowledge of weed growth patterns, the reproductive potential of specific weeds, and weed competition with desirable plants. One of the more important questions before considering control is to ask why weeds occur and if there other similar or nearby sites without weeds. Many common weed problems occur because of conditions favoring their growth such as, overgrazing, overuse, clear_cutting, improper mowing of road edges, rain water run_off from roads, importation by vehicles, and/or repeated use of herbicides. Attempting to control weeds under such circumstances is very difficult and expensive. Long_term weed growth in an area, for instance, has probably produced innumerable seeds that can remain viable in the soil for decades. Sometimes, when costs and other rationale are considered, it is found that a greater percentage of weeds can be tolerated than at first thought.

The first step in effective weed control is to identify target weeds so proper management methods can be applied. Following identification, alternative control methods include physical or mechanical, cultural, and chemical techniques. Regardless of the control method(s) selected, actions should always coincide with the time period(s) when weeds are in their most vulnerable stage and most susceptible to attack. The most important, effective, and longest_term weed control is had by cutting or killing weeds before they produce mature seeds.

Physical and mechanical weed control includes such activities as mowing or cutting, hand pulling, burning or flaming, disking or plowing, mulching, etc. Often, physical and mechanical controls do not require any more time than spraying of herbicide, do not present the hazards surrounding use and storage of toxic chemicals and do not require NPS approval.

Manual controls such as hoeing, digging, pulling, cutting, girdling, and burning are designed to prevent seed production, prevent seed germination, and to destroy top growth when the plant is least able to recover. Mowing may be used to stress taller weed plants (prevent nutrients moving to the roots) while decreasing competition to shorter, desired plants. Disking can be used to prevent seed production, encourage seed germination, dry out vegetation before root establishment, and change soil conditions (reduce compaction which favors some weeds). Burning suppresses broad_leaf weeds and shrubs and favors grasses. Mulching prevents weed seed germination.

These are desirable and relatively selective techniques; however, most aggressive weeds tend to sprout from root stocks following mechanical controls and, at least for some sites, inaccessibility or logistical hazards may limit the efficacy and safety of control efforts (i.e. steep slopes). Other disadvantages of physical and mechanical weed controls may include:

Mowing does not quickly kill many weeds and, if not done when plants are small, can result in a large amount of flammable and unsightly rubbish which must be removed. Continual cutting, however, will over time exhaust nutrients stored in the plant roots and ultimately kill the plant.

Hand pulling weeds allows for control of weeds before they bloom; however, small pieces of roots are almost always left in the soil and these can sprout to produce new weed plants.

Flaming (agricultural torch) is most effective while plants are still small. Similar to mowing, considerable dead plant debris is left after large plants are flamed. Flaming is labor_intensive and, for sizeable areas, presents problems surrounding the uniformity of treatment and transport of equipment unless tractor_mounted flamers are used. Disturbance of soil surfaces by tractors or heavy equipment is not desirable in many NPS areas and further encourages weed invasion. Flaming may require burn permits.

Controlled burning of entire fields can only be done when plants are large enough and stems are dry enough to carry fire. And, these conditions are usually only present after weed seeds have matured and are in the soil. Burning weeds poses a number of safety hazards and is not very selective.

Disking and plowing require heavy equipment and damage soil surfaces (detrimental in archeological areas) which

causes increased rates of wind and water erosion and renewed weed invasion.

Mulching (with weed fabric or plastic sheets) is only practical for small, selected sites (i.e. around trees, specific archeological sites) and is not an efficient method for larger areas.

A somewhat new strategy in weed control is that found in the Bradley method ("artificial selection" against weeds) for eliminating exotic or unwanted plants. Although Bradley uses the same physical and mechanical control alternatives as noted above, it does so in a very persistent, long_term manner. Bradley advises to not attempt clearing weeds from large areas at one time _ this only produces large stretches of bare, open soil that further encourages weed recolonization. Bradley recommends the removal of weeds from only relatively small areas (no larger than can be effectively and methodically covered) about once a month throughout the growing season. Weeds occurring singly or in groups of 4 or 5 plants are mechanically removed and then native vegetation is allowed to re_establish before the control areas are expanded. Areas containing solid weed infestations are not worked until native vegetation has reappeared right up to the weed line. Continually work weed patches but only along the edges so as to form small clearings of less than 6 feet in diameter where native vegetation can reestablish.

The Bradley method would be effective for small, decorative areas in front of or around buildings and along high_use trails and could be easily combined with selective chemical spot_treatments (use of a wick applicator).

Preventing establishment of weeds is the most important measure for weed control. This is done by preventing, if possible, weed seeds from being transported into an area and becoming established, keeping weeds from going to seed, and limiting the spread of perennial plants which reproduce vegetatively.

Established ornamental plantings. Preventing weed invasion is always easier than trying to control weeds after they appear. Use good cultural practices in lawns and ornamental plantings which include regular soil testing, proper timing for fertilization and liming, proper mowing height and timing, and adequate but not excessive irrigation. Frequent shallow irrigation lessens the vigor of turf grass roots and encourages weed germination. Continually remove debris and heavy thatch from lawns and reduce soil compaction with core aeration.

New ornamental plantings. When planting or renovating sites, plant them with only species adapted to local environmental conditions and, as possible, species which are resistant to diseases and insects. Fall is the best time to renovate cool_season grasses and spring is the best time to renovate warm_season grasses.

Pavement cracks. To control weeds in pavement cracks, repair any surface defects and remove accumulated organic debris and weed growth from the cracks before filling the cracks with mortar, tar, caulking, etc. which prevent new weed establishment. Sometimes, however, persistent weeds will even grow through the material used to fill cracks and will have to be removed again. When feasible, covering weeds in cracks for a few days during summer with plastic mulch (1.5 to 4_mil thickness) will kill weeds like pigweed, crabgrass, foxtail, quackgrass, thistles, and bindweed.

The agricultural flamer is a good mechanical alternative for herbicides for weeds in cracks and usually presents little fire hazard. Flame is not applied to burn weeds out (incinerate them), rather to only cause permanent wilt which kills the plants by expanding and rupturing plant cells, coagulating protoplasm, deactivating enzymes, and removing cellular liquids. Although only 113 to 140_F. is needed to accomplish most plant cell thermal death, many dry seeds are tolerant of high temperatures and require prolonged exposure. However, too much heat applied to plants can stimulate growth from remaining roots. Only a brief contact with heat (i.e. a light "searing" or wilting, to 140_F.) is needed to kill or severely damage plants. Plants are most susceptible as young seedlings (1 to 2_inches tall) and while in the 3 to 5 leaf stage. Broad leaf weeds are more susceptible to heat than grasses.

When grasses are about 1_inch tall, a protective sheath develops around the leaf and protects growing points from heat and allows tillers to resprout. Flaming grass plants will not kill them; however, and especially if applied during early season, heat severely sets plants back and limits their seasonal growth potential.

Wild areas. Preventing weeds from invading wild areas (roadsides, unkept fields, trails, etc.) is very difficult.

Climate, herbivores, man_caused or natural disturbances to the soil, wide variations in available moisture, importation by vehicles or wind or water run_off, improper use of herbicides, and many other factors reduce the health and vigor of native vegetation and/or open areas to allow for new weed colonization.

As possible, control of weeds in wild areas is necessary to prevent maturation or dispersal of seed and weed establishment in developed areas. Non_chemical controls which prevent the development of weed seed include mowing or cutting, hoeing, hand pulling, burning or flaming, disking or plowing, mulching (plastic sheets) etc. Some of these controls, though meaningfully done, are counter_productive because they may invite renewed weed growth by disrupting the soil, scattering seeds, or leaving live root parts in the soil.

The best methods for weed control in wild areas are those that do not alter soil surfaces but selectively reduce the viability of weed plants by decreasing stored energy reserves in the roots and preventing seed formation. Such control requires good knowledge of the weeds present and their phenology in the area as well as careful timing of selected and specific weed control measures. And, different control techniques are usually required for different plant habitats. Plastic mulching may be feasible in some sites. But, flaming (agricultural torch) or burning often stand out as the most practical and least disruptive techniques for controlling weeds in wild areas but also pose significant hazards for initiating destructive wild fires unless preventative measures are taken.

Chemical management

Today, most weed control is done with hormone like, organic chemicals (herbicides). Controlling weeds with chemicals typically seems easier, quicker, more efficient, and more economical than physical or mechanical controls.

However, chemical weed control does have many associated problems. It is not usually as selective as physical/mechanical methods, can damage desirable plants, and leave long_lasting chemical residues in the soil or introduce them into the environment. Chemical weed control requires specific knowledge to be able to select proper herbicides. And, it may stimulate plants to develop herbicide resistance, cause secondary pest weed problems, and pose a variety of health hazards and logistical problems for applicators.

Increased selectivity for chemical applications with basal bark, stump, and wick applications are preferred methods for managing weeds in NPS areas.

When it is not practical to control weeds by cutting stems and treating them with herbicides, it may be necessary to broadcast or use chemicals over a wide area. Even though wide area treatments can be effective, the use of relatively short_residual, chemicals _ without making accompanying physical changes in the habitat (or otherwise altering conditions supportive of weeds) _ only results in the undesirable need to repeatedly apply and depend on chemical treatments. Requests for use of chemical herbicides should be accompanied with program designs describing how long_term weed control will be achieved without a dependence on herbicides (by changing environmental conditions, increasing plant competition, reducing moisture or light, etc.).

Pre_emergent herbicides are chemicals applied to soils to keep weed seeds from germinating. Postemergent herbicides are applied to actively growing plants following germination and can be either selective chemicals (affecting only specific kinds of weeds) or non_selective chemicals (killing all plant life). Pre_emergent herbicides are usually applied over general areas. Post_emergent herbicides are best used as spot treatments which only contact a target weed and can be done through pin_point applications with a brush, wick, protective collar, or controlled spray.

Annual grassy weeds. Pre_emergent herbicides (such as benefin) are usually effective for controlling annual grassy weeds. These chemicals are normally applied 10 to 14 days before weed seed germination (usually about the time lilacs bloom). Post_emergent chemical control (as glyphosate, siduron, dalapon) of grassy weeds is most effective when applied early in the growing season while plant tissues are rapidly dividing and before plants mature and produce seed.

Perennial weeds. Chemical control of perennial weeds, however, is more effective at the end of the growing season

when nutrients produced by the plants are being translocated from the leaves for storage in the roots. Depending on the type of weed, chemicals commonly used for perennials include glyphosate, 2,4_D, triclopyr, and dalapon.

Chemical herbicides have many disadvantages but are many times the only practical solution for weed problems. The first step in any weed control program is to identify the plants so weakness in their physiology or life cycle can be applied for maximum control.

Pavement crack and other weeds. In general:

Annual grasses and weeds. Apply pre_emergent herbicide during late winter or early spring or apply glyphosate when weeds are actively growing.

Spot_treat grass_like weeds in pavement cracks with glyphosate or herbicidal soaps (with a controlled spray or wick application) while plants are still small and actively growing. Repeat applications in 6 to 8 weeks, as needed. For difficult to control weeds, repeat applications every 10 days until control is obtained.

A relatively new pre_emergent herbicide is available and may be approved by the NPS is AgrEvo's Finale Weed and Grass Killer (glufosinate ammonium). This material is described as causing a buildup of ammonium in plants and kills weeds in a few days. The active ingredient is reported to quickly break down in the soil into natural fertilizing compounds.

Broad leaf weeds. Spot_treat broad leaf and perennial weeds with glyphosate, triclopyr or 2,4_D. The best control is had when plants are young or actively growing and before seed set. Treat plants during the spring or fall. Do not allow plants to set seed.

Weeds with hairy leaves are harder to control. If a herbicide will not adhere to the leaf surface (i.e. wild violet), use a mixture of turflon and 2,4_D.

Pre_emergent benefin is effective for treating crabgrass areas during early spring before sprouting begins. Minimize all herbicide contact with other plants.

Black locust, sumac, white poplar, Russian olive, and tamarix must be cut to a ground level stump and painted with Garlon at rates recommended on the label. Cutting alone does not kill these species as they all resprout from stump or roots.

Approved Chemical Alternatives at NEPE:

2,4_D _ for broadleaf weeds in grass
Garlon
Glyphosate _ non_selective herbicide
Picloram _ for woody plants

Other chemical alternatives that must have prior approval include:

Benefin
Dalapon _ for annual grass in broadleafs or perennial grass in broadleafs
Siduron _ for annual grass in grass
Triazines _ for perennial weeds in grass
Triclopyr _ for woody plants

Resources

Materials Available

Materials available include hand tools (eg. shovels, rakes, pruners, etc.), gloves, and approved chemical treatments.

Technical Experts

NPS-WASO IPM Coordinator, Columbia Cascades Cluster IPM Coordinator, and/or the County Extension Agent for the area.

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MOSQUITOES

While mosquitoes remain a major killer in other parts of the world, in the United States, mosquitoes are not the scourge they once were. But they're still irritating, they still bite us, and there are some species in the United States that spread disease. Mosquitoes also serve a vital ecological function. The larvae, pupae, and adults are important as food for fish, birds, bats, frogs, and insects - an essential consideration when the subject of mosquito control arises in a national park.

The one thing that all mosquitoes require to complete their life cycle is water. If people could manage all standing water, we could manage mosquitoes. While we can fill in a puddle, we don't want to fill in a salt marsh. We can empty a bucket, but it's not so easy to empty a tire dump.

Biology and Identification

While there are more than 13 genera of mosquitoes in the United States, most pest mosquitoes belong to one of three: Aedes, Culex , or Anopheles.

Aedes

Some Aedes mosquitoes are called "floodwater mosquitoes" because they lay their eggs singly on damp soil or vegetation in areas that are periodically wet. The eggs can remain dormant until they are flooded and conditions are favorable for hatching. Salt marsh species breed in coastal marshes that are occasionally flooded by high tides. Many floodwater and salt marsh species can fly great distances (5 to 20 miles) from their hatch site. Other Aedes species prefer to lay their eggs in artificial containers or tree holes. Again the eggs are laid just above the water line and hatch once they are inundated.

The Asian tiger mosquito, *Aedes albopictus*, first appeared in the United States in 1985. Its rapid spread is of concern because it is known as a disease-carrying mosquito in its native Asia. It also breeds readily in water-filled containers, so breeding sites are commonly available.

Culex

These mosquitoes breed in quiet standing water of all types, ranging from containers to larger pools. Culex species prefer polluted standing water with large amounts of organic material. Eggs are laid on the water surface in "rafts," of 100 or more eggs. While Aedes and Anopheles mosquitoes have a pointed tip at the end of the abdomen, Culex mosquitoes have a blunt tip.

Anopheles

Anopheles mosquitoes breed in permanent bodies of fresh water. They prefer water with abundant aquatic plants that provide protection from fish and other predators. Eggs, supported by floats on each side, are laid singly on the surface of the water.
Anopheles mosquitoes can be distinguished from Aedes and Culex mosquitoes in several ways: (1) Anopheles have patterned wings, (2) adult Anopheles females have palps that are almost as long as their proboscis, (3) adults rest on surfaces with their head lower than the abdomen while Aedes and Culex species rest with the head and abdomen parallel to the surface, and (4) the Anopheles larvae float parallel to the water surface rather than hanging down at an angle.

Of the four life stages of the mosquito--egg, larva, pupa, and adult--the adult is the only stage that doesn't exist in standing water.

The female mosquito lays her eggs on the water or, in the case of Aedes mosquitoes, above the water in areas that are sheltered from waves and with sufficient organic matter to feed the larvae. Eggs laid on the water's surface hatch in one to three days. Eggs laid by Aedes mosquitoes above the water line remain dormant until they are flooded.

The larvae or "wigglers" that hatch must live in water to survive. They float at the surface breathing through an air tube and filtering food material through their mouth brushes. When disturbed, they dive towards the bottom with a jerking motion. Larval stages last from five days to several weeks depending on species and environmental conditions (e.g., water temperature).

The larvae transform into pupae or "tumblers." Although the pupae don't feed, they are quite active and may be seen breathing at the surface or bobbing through the water. Inside the pupal skin, the adult mosquito is developing and will emerge in two to three days. Mosquitoes pass the winter either in the egg stage or as adults.

Only the female mosquito sucks blood, which she needs to lay eggs. Adult male mosquitoes feed only on plant nectar and are harmless to people.

Most mosquitoes feed just after dark and again just before daylight. They spend the daylight hours resting in dark, damp areas. Some mosquito species, however, feed during the day and others may feed during both day and night.

This blood-sucking habit is what causes certain species of mosquitoes to be disease vectors. If a female mosquito sucks blood from a person infected with malaria, for instance, the disease organisms survive and reproduce in the mosquito, ending up in her salivary glands. When she next feeds on a host, she inoculates her new victim with the disease.

Larval mosquitoes feed on organic debris (with the exception of a few species that are predators). They use a pair of mouth brushes to strain out small aquatic organisms and particles of plant and animal material present in the water.

Mosquitoes may breed and develop any time from the beginning of spring to the first hard frost of fall. In general, populations are highest in summer and early fall. There may be several generations of mosquitoes during a season depending on the species, the temperature, and the amount of rainfall.
When rainfall is abundant, many species can lay eggs continuously. Under ideal conditions with high temperatures, development can be completed in less than a week, resulting in large populations of flying adults.

Occurrence in the Park

Mosquitoes may be found in all locations of the park where appropriate habitat is found, particularly in those places close to riparian areas at Big Hole, White Bird, and Spalding.

Potential Damage and Health Concerns

Worldwide, mosquitoes transmit many debilitating and fatal diseases, especially in tropical, developing countries. The most important of these is malaria, which has been on the increase in the last decade. In the United States, mosquitoes are primarily an annoyance, causing itching bites and welts that can become secondarily infected. Human mosquito-transmitted diseases remain relatively rare, due largely to modern pest control methods and disease detection. Encephalitis, among humans, and dog heartworm, among dogs, are the main diseases transmitted in the United States

At least six types of mosquito-transmitted encephalitis occur in the United States. These are eastern equine encephalitis, western equine encephalitis, California encephalitis, St. Louis encephalitis, Venezuelan equine encephalitis, and La Crosse encephalitis. Each type is caused by a different virus or virus complex affecting the central nervous system. These viruses are normally transmitted by mosquitoes from birds or small mammals. Occasionally horses or humans are infected. Despite the small number of people infected annually by eastern equine encephalitis, it is considered a serious disease because it is often fatal.

Dog heartworm is a filarial parasitic disease transmitted by a number of different mosquitoes to dogs and, rarely, man. Once a problem only in coastal areas, dog heartworm is now found in every state in the United States. The nematodes, which lodge and grow in the heart tissue, can be fatal to dogs if left untreated.

There has been some concern about whether mosquitoes are capable of transmitting AIDS from an infected person

to an uninfected person. Unlike encephalitis viruses and other mosquito-transmitted diseases, the HIV virus that causes AIDS is not able to survive inside the body of the mosquito. Researchers say it's virtually impossible that a mosquito could transmit AIDS.

Monitoring and Thresholds

Sampling and counting the mosquito population accomplishes a number of things. It helps determine whether mosquito control is necessary. It determines what growth stage the mosquitoes are in, providing information necessary to time control methods. It tells which mosquito species are present, especially important in areas of disease outbreaks. Finally, it helps to gauge how effective control efforts have been and when they need to be employed again.
Sampling should be done at least once a week, and more often during peak season. It is important to consistently sample the same sites each time. The numbers counted, the growth stage, and the species and sex should be noted when possible. All of this information gives an estimate of the population and must be compared with previous counts to determine whether the number of mosquitoes are increasing or decreasing.

Estimates of mosquito populations in an area may be obtained by both larval and adult counts.

Larval dippers can be purchased through biological supply houses or you can make your own. It is basically a shallow, plastic, enamel, or aluminum cup attached to a long handle. To collect floating mosquito larvae and pupae, depress one end of the dipper under the surface and quickly but smoothly scoop up larvae. If you move too quickly or cast a shadow on the surface, they will dive to the bottom.

The number of dips at each site will vary according to the size of the water body, but generally are in multiples of ten. Take five dips from open water and five from the water's edge, near vegetation if possible. Dipper inspections should be made weekly during the breeding season. Larvae can also breed in rainwater that has collected in containers such as buckets, garbage cans, canoes, tires, and animal watering troughs. To sample larvae in less accessible areas such as tree holes, use a large basting syringe to collect them. Empty them into a white pan for counting.

One advantage to sampling larvae is that the problem can be treated at the same time it is identified. When counting adult mosquitoes, the mosquitoes can be flying in from some distance away.

Trapping adult mosquitoes gives information on relative population size and species composition. Light traps are useful for monitoring certain species of mosquitoes. Not all species are attracted to lights and different trap models vary in the number, species, and ratio of females to males they catch.

New Jersey light traps and CDC light traps (and their variations) are the traps most commonly used. Light traps are operated from dusk to dawn, powered either by electric line or a battery. Some traps are available with photoelectric cells that turn the light on at dusk and off at dawn. When mosquitoes approach the light, they are blown by a small fan down through a funnel into a killing bag or jar.

The light trap should be hung about 6' off the ground in an open area near trees or shrubs but away from competing lights and buildings. Traps should be emptied each morning and the catch stored in a labeled box until it can be sorted and identified.

Since mosquitoes are attracted to carbon dioxide in the host's breath, some light traps are augmented with a one pound block of dry ice, wrapped in newspaper and hung next to the trap. The addition of dry ice also allows sampling on moonlit nights or in areas where bright lights may conflict with the light trap. And it allows daytime sampling of species that are active during the day or that are not attracted to lights.
Because some species are not attracted to light traps, they should be used in conjunction with other kinds of sampling methods. Monitoring for adult mosquitoes is an important part of the management of some mosquito-vectored diseases such as eastern equine encephalitis. The decision to use pesticides for mosquito suppression is made only after intensive monitoring of the mosquito population in an area to determine if the species that vectors the disease to humans is present. The incidence of the disease in the wild animal population is monitored as a way

to estimate the possibility of transmission to humans. Visitor education is also emphasized to alert people to the presence of the disease and how to go about protecting themselves.

Collecting mosquitoes as they land to bite is a convenient method of sampling biting populations. It involves rolling up a sleeve or pants leg and sitting quietly for a designated period of time, usually 10 minutes. During that time, each mosquito that lands on the leg or arm is collected with a battery or mouth-operated aspirator. It is important that you collect the landing mosquitoes for counting and identification and to ensure that you don't count the same individual again. Biting counts are best conducted from 30 minutes before sunset to 30 minutes after sunset (unless sampling day-biting species) by the same person each time.

The advantage to using landing counts as a sampling device is that you are counting only biting mosquitoes. The method does not collect male mosquitoes or species that do not actively bite people. It can also be used to count and collect daytime biters.

When sampling adult mosquitoes, sample all areas where mosquitoes may be a nuisance. Sample areas from which you have received complaints and near areas with high larval or pupal counts. Sample the same sites regularly, from one to seven nights a week. Adult mosquito information is most useful in gauging the extent of the mosquito problem, since it is the adults which transmit disease or create a nuisance.

Data from sampling and monitoring will be used to help decide at which infestation level to initiate management tactics. This decision level will be based on larval and adult counts, complaints from visitors, the potential for disease outbreaks, and the risk of the management tactics to other animals.

The number and location of visitor or neighbor complaints should be plotted on a graph against the counts of immatures and adults for the same date and site. The amount of unacceptable complaints is the injury level. The graph should show the number of mosquitoes that correspond to the complaint injury level. This is the action level.

Action levels are different for each situation. In some areas, general annoyance does not occur until the number of female mosquitoes caught in light traps exceeds 25 per night. Other action levels that have been used are landing rates averaging more than 5 mosquitoes in 10 minutes and dipper counts averaging 5 larvae per dip. However, in most National Park Service locations, the action level would be higher than in a suburban neighborhood.

Non-chemical Control

The key factor in a mosquito integrated pest management program is determining whether or not control is necessary. This decision requires a regular mosquito sampling program to determine what species are present and in what numbers, and a set of action thresholds to determine if management tactics are necessary. If control is needed, then decisions have to be made on the best combination of tactics to suppress the mosquito population while affecting the environment as little as possible.
Normally, source reduction--eliminating or altering the water so that the mosquitoes cannot breed or complete their life cycle--is the first choice for control. If source reduction is impossible or incomplete, the next tactic to consider should be biological control of the larvae with predators, bacterial insecticides, or growth regulators. Visitor education also represents an essential part of a mosquito integrated pest management program at national parks. Interpretive displays can be used to explain the role of mosquitoes as a food source for animals such as bats, birds, and fish, and to help visitors understand that not all mosquitoes bite or carry disease. Personal protection through the use of proper clothing and repellents can be explained, as well as the avoidance of areas with high mosquito populations.

The simple fact that all mosquito species require water to develop is the key to their control. No standing water means no mosquitoes. Source reduction is the first step in an integrated pest management program for mosquitoes. It is simply the use of mechanical methods to eliminate standing water. Source reduction involves filling, deepening, draining, ditching, managing water levels, maintaining shorelines, managing aquatic and inundated vegetation, and others. While these methods may prove to be more extensive and more expensive than some other controls, in most cases they need be done only once. Unfortunately, these methods will most likely require

permitting from several agencies before they can be implemented. They are also not feasible in natural zones of a park.

Source reduction controls the immature mosquito stages--eggs, larvae, and pupae. Because these stages are concentrated in discreet bodies of water, they are much easier to control than are dispersed adult mosquitoes. Two water management tactics are ditching and ponding. That these would only be allowed in a developed zone. Ditching controls mosquitoes in two ways. In some cases water drains out of the potential breeding sites. In others, ditching allows fish access to the isolated pools where they prey upon the larvae and pupae. Ponding is another water management tactic that turns a temporary pool breeding mosquitoes into a permanent one capable of supporting fish and other mosquito predators. Ponding is accomplished by raising the water level, digging new pools, or through impoundment.

If standing water can't be eliminated, control of mosquito larvae in the water is the next step. This is best done with natural controls such as mosquitofish or biorational insecticides. The latter do not affect pupae and should not be used if this is the predominant life stage.

Fish are the most important predator of mosquito immatures. Mosquitoes are rarely a problem in a body of water that also contains fish. To use fish as a biocontrol agent the water must be deep enough and must have the right combination of environmental conditions to sustain fish. Introduced fish must have protection from native fish and other aquatic predators. No water bodies within the park possess the above conditions, therefore the use of mosquito eating fish in not an option at this time.

Various commercial products containing *Bacillus thuringiensis israelensis* (B.t.i.) are available for treating bodies of water. This bacteria kills mosquito and blackfly larvae. It is nonhazardous to humans, other animals, fish, and predacious insects. B.t.i. is available as granules, slow release briquettes, or wettable powder. It can be applied by hand, with a backpack blower or granule spreader, or by aircraft.

Because the released bacterial spores must be ingested by the larvae, B.t.i. is not effective against eggs, pupae (which do not feed), or mature larvae that are ready to pupate and have stopped feeding.

Mosquito larvae are an important food for aquatic organisms. Large numbers fall prey to fish, insects, and spiders. Naturally-occurring bacteria, protozoa, fungi, and nematodes also kill mosquito larvae. Both bacteria and predatory fish have been used as biocontrol agents to control mosquito larvae. Adult mosquitoes are fed upon by birds, bats, frogs, lizards, spiders, and insects.

Screening of doors, windows, and vents is a time-honored method of keeping mosquitoes out of structures. Ordinary window screen of 16 x 16 or 14 x 18 meshes to the inch will keep out most mosquitoes. Campers can hang mosquito netting over cots, tent openings, picnic tables, etc. Long sleeves, long pants, hats, and veils give additional protection from mosquitoes.

Insect electrocuters, or "bug zappers," do not effectively control mosquitoes. Many mosquitoes are not attracted to the light. Tests in residential areas have shown that only a tiny percentage (usually less than 3%) of the insects killed are mosquitoes. Most are harmless gnats, moths, and beetles.

Chemical Control

Insect growth regulators such as methoprene do not kill the larvae but prevent them from developing into adults. Timing of application is important since only mature larvae are affected. Larvae that have already pupated will continue to develop into biting mosquitoes. Methoprene can be applied as slow-release briquettes, granulars, or ground or aerial spray. Most insect growth regulators do not harm other nontarget species.

Since methoprene does not kill the immatures, you will still collect larvae and pupae in dip counts. The only way to determine whether the treatment was effective is to rear the collected larvae and pupae and observe whether they develop into adults.

Petroleum oils or specialized mineral oils can be applied to the water. The oil forms a thin film over the surface which suffocates eggs, larvae, and pupae. In the presence of wind, waves, or rain, the oil film breaks up and is less effective. Some oils are toxic to fish, other organisms, and aquatic plants. Various insecticides can be applied to the water as dusts, granulars, wettable powders, or emulsions. Pesticides will likely kill other aquatic insects and may be harmful to fish, birds, and mammals.

Adulticiding is space spraying for adult mosquitoes with insecticides. With an effective source reduction and larviciding program, adulticiding should not be necessary. It is generally the last resort in an integrated mosquito control program, since spraying of adult mosquitoes provides only temporary relief. It must be repeated frequently to intercept new mosquitoes moving into the area. Adulticiding may be the only feasible management strategy in a natural area where mosquitoes pose a public health risk, since source reduction is prohibited.

Most adulticiding is accomplished with a truck-mounted, ultra-low volume sprayer. Depending on the size of the area to be controlled, other application methods include backpack or power sprayer, mist blower, thermal fogger, or application from aircraft. Spraying is usually done in early evening when winds are less than 6 mph. Ground spraying is not possible in most natural areas.

Personal insect repellents containing DEET applied to skin or clothing provide protection from biting. Another repellent, permethrin, may be used on clothing only. Jackets and tents impregnated with repellents are also available.

Approved Chemical Alternatives at NEPE:

Personal insect repellents containing DEET and/or permethrin.

Other chemical alternatives that must have prior approval include:

Methoprene;
Petroleum oils.

Resources

Materials Available

No materials available.

Technical Experts

Since these instances are of such an occasional manner, no technical experts are listed. The best place to start would be to consult with the County Extension Agent for the area.

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MUSEUM PESTS

A pest in a museum can cause far more damage than the same pest in a home or an office building. Carpet beetles in a stuffed bear, clothes moths in a native American headdress, or cigarette beetles in a herbarium can destroy irreplaceable artifacts. But while museum specimens must be protected, their sensitivity to chemical and environmental stresses means that standard pest control procedures are often unacceptable. Liquid pesticides may stain certain materials, heat treatment can damage paintings, dusts can abrade sensitive specimens. Caution is the byword in museums.

Each pest problem must be analyzed on its own. Before taking any action to control a pest, be sure that actions will not themselves damage the museum's collections. Use of pesticides may at times be necessary, however indiscriminate use or dependence on pesticides is unacceptable.

Any pest with chewing mouthparts is a risk to museum specimens. Carpet beetles, clothes moths, powderpost beetles, cockroaches, and others pose direct threats to specimens through feeding damage, feces, and excretions. Some pests pose indirect risks such as fire (rodents gnawing on wires) and secondary infestations (dead cluster flies in attics can attract carpet beetles).

Identification and Biology

Any pest that infests houses, restaurants, or other buildings may at some time become a pest in a museum. Certain pests, however, repeatedly threaten museum collections. They can loosely be grouped into five categories:

(1) Fabric pests
(2) Wood pests
(3) Stored product pests
(4) Moisture pests
(5) General pests

The first step in solving any pest problem is to identify the pest and learn about its biology and habits. While it is impossible to discuss each pest in detail in this manual, the brief discussions below may help you understand a little about the habits of the pests most likely to infest museums or damage museum specimens.

Fabric Pests

Most insect damage to fabrics is caused by carpet beetles (in the family Dermestidae) or clothes moths (in the family Tineidae). The adults stage is seen most often seen since adults fly and some are attracted to lights and windows, but it is not the adult insects that do the damage. They feed outside on pollen or not at all. It is the larva or immature stage that feeds on fabric, fur, feathers, or virtually anything made of animal fibers.

Carpet Beetles

Immature carpet beetles feed on dried animal products such as wool, silk, felt, hair, fur, feathers, dead animals, and stuffed trophy heads. They do not feed on synthetic fabrics, but sometimes damage wool-synthetic blends or synthetics stained with urine, sweat, or food.

Carpet beetle larvae are repelled by light and are usually found burrowed deeply into infested material or in little-used drawers, cases, and storage bins. To grow, they molt and shed their skins. In heavy infestations, you may find large numbers of these light-colored shed skins. The adults are often seen crawling up walls and congregating on window ledges.

There are many species of carpet beetles. Also, many common beetles resemble carpet beetles. Be sure to get the pest beetle properly identified so that you can zero in on the infested goods and likely harborage sites. Four species of carpet beetle are most likely to be found in museums.

Black carpet beetle (*Attagenus unicolor*) is the most abundant and destructive of the carpet beetles. The adult is 1/8"- 3/16" long, a solid dark brown or dull black color, and more elongate than carpet beetles described below. The larva is less than 1/4" long and carrot-shaped. It is covered with golden brown hairs and has a characteristic "tail" of long hairs at the rear end.

Varied carpet beetle (*Anthrenus verbasci*) is primarily a scavenger. It is common in the nests of birds, on dead animals, and in insect collections, but can damage woolens, carpets, wall hangings, hides, horns, and bone artifacts. Small populations often go unnoticed behind furniture or along baseboards feeding on accumulated lint, hair, food crumbs, dead insects, and other organic debris. The adult is about 1/8" long, oval to round, with splotches of white, yellow, and black on its back. The larva is tear-drop shaped and covered with rows of light brown hairs.

Common carpet beetle (*Anthrenus scrophulariae*) attacks carpets, woolens, and animal products such as feathers, furs, leather, silks, mounted museum specimens, and pressed plants. The adult is about 1/8" long with a band of orange scales down the middle of its back. The larva is reddish-brown and covered with brown or black hairs. A mature larva is active and moves rapidly.

Furniture carpet beetle (*Anthrenus flavipes*) attacks furniture (particularly old horsehair-stuffed furniture) and items made from wool, fur, feathers, silk, horns and tortoise shell. Adults are about 1/8" long, rounded, and blackish with variable mottling of yellow and white scales on the back and yellow scales on the legs. The larva is difficult to tell from the common carpet beetle.

Clothes Moths

These are small, silvery-beige moths with a wing span of less than ½". They have narrow wings fringed with long hairs. Small grain and flour-infesting moths are often confused with clothes moths. However, clothes moths have different flying habits. They avoid light and are rarely seen flying. They prefer dark corners, closets, and storage areas, and usually remain out-of-sight.
The primary food of clothes moth larvae is soiled woolens, but they also feed on silk, felt, fur, feathers, and hairs. In museums they often damage woolen clothes (particularly old military uniforms), feather hats, dolls and toys, bristle brushes, weavings, and wall hangings.

The webbing clothes moth (*Tineola bisselliella*) and the casemaking clothes moth (*Tinea pellionella*) are the two most common clothes moths found in museums. The larvae are small white caterpillars with brown heads. They feed on the surface of the material infested. The webbing clothes moth produces feeding tunnels of silk and patches of silken webbing on the fabric's surface. The casemaking clothes moth is rarely seen since it constructs a cylindrical case of fabric which it carries around to hide and feed in. The color of the larva's case can help you locate infested materials.

Wood Pests

Materials made of wood are susceptible to attack by a number of wood- infesting pests. The culprits in museums are usually powderpost beetles or drywood termites. Both can severely damage valuable artifacts while remaining invisible to the untrained eye.

Powderpost Beetles

These are a group of beetles in the insect families Anobiidae (anobiid, furniture, and deathwatch beetles), Lyctidae (true powderpost beetles), and Bostrichidae (false powderpost beetles). The term "powderpost" comes from the fact that the larvae of these beetles feed on wood and, given enough time, can reduce it to a mass of fine powder.

Powderpost beetles spend months or years inside the wood in the larval stage. Their presence is only apparent when they emerge from the wood as adults, leaving pin hole openings, often called "shot holes," behind and piles of powdery frass below. Shot holes normally range in diameter from 1/32" to 1/8", depending on the species of beetle. If wood conditions are right, female beetles may lay their eggs and reinfest the wood, continuing the cycle for generations. Heavily-infested wood becomes riddled with holes and galleries packed with a dusty frass (wood that

has passed through the digestive tract of the beetles). Both hardwood and softwood can be attacked by powderpost beetles, although lyctids only infest hardwoods.

Items in museums that can be infested by powderpost beetles include wooden artifacts, frames, furniture, tool handles, gun stocks, books, toys, bamboo, flooring, and structural timbers.

Drywood Termites

Unlike their cousins the subterranean termites, drywood termites establish colonies in dry, sound wood with low levels of moisture, and they do not require contact with the soil. They are primarily found in the coastal southern states, California, and Hawaii, but they are easily transported to northern states in lumber, furniture, and wooden artifacts.

Drywood termites attack wooden items of all kinds. The termites feed across the grain of the wood, excavating chambers which are connected by small tunnels. The galleries feel sandpaper-smooth. Dry, six-sided fecal pellets are found in piles where they have been kicked out of the chambers. The pellets may also be found in spider webs or in the galleries themselves.

A swarming flight of winged reproductive termites can occur anytime from spring to fall. Most drywood termites swarm at night, often flying to lights.

Stored Product Pests

Many museums include items made in part of seeds, nuts, grains, spices, dried fruits and vegetables, and other foods. A long list of pests, traditionally called "stored product pests" or "pantry pests," can infest items containing these foods. Probably the most common of such pests in museums are the cigarette beetle and the drugstore beetle.

Cigarette beetle (*Lasioderma serricorne*) is named for the fact that it is a pest of stored tobacco, but is also a serious pest of flax, spices, crude drugs, seeds, and, most importantly for museums, books and dried plants. This beetle has been called the "herbarium beetle" because of the damage it can cause to dried herbarium specimens. It has also been found infesting rodent bait.

The adult beetle is light brown, 1/8" long, and the head is bent downward so that the beetle has a distinctive "hump-backed" look. It is a good flier. The small larva is grub-shaped and whitish, with long hairs that make it appear "fuzzy." It has yellow- brown markings on the head.

Drugstore beetle (*Stegobium paniceum*) feeds on a wide variety of foods and spices (particularly paprika or red pepper). It is also a serious pest of books and manuscripts, has been reported "feeding on a mummy," and has been known to chew through tin foil and lead sheeting.

The adult beetle is very similar to the cigarette beetle. With careful examination through a magnifying lens, the drugstore beetle may be distinguished by its three- segmented antennal club. The larva, too, is similar, but does not appear as "fuzzy."

Moisture Pests

Moisture is not only a threat to museum specimens on its own, it may attract a number of moisture-loving pests that can do additional damage. The most important of such pests are the molds and insects in the order Psocoptera that feed on those molds.

Molds are fungi that can cause damage or disintegration of organic matter. Basically plants without roots, stems, leaves, or chlorophyll, molds occur nearly everywhere. When moisture and other environmental conditions are right, molds can appear and cause significant damage to wood, textiles, books, fabrics, insect specimens, and many other items in a collection. Their growth can be rapid under the right conditions.
It is important to realize that fungal spores, basically the "seeds" of the fungus, are practically everywhere. Whether

molds attack suitable hosts in a museum depends almost exclusively on moisture. When moisture becomes a problem, molds will likely become a problem too.

Although psocids are commonly called booklice, they are not related to parasites such as head lice or body lice. Booklice got that name because they often infest damp, moldy books. They feed on the mold growing on paper and in the starchy glue in the binding. Psocids also infest such items as dried plants in herbaria, insect collections, manuscripts, cardboard boxes, and furniture stuffed with flax, hemp, jute, or Spanish moss.

Psocids do not themselves cause damage. They become pests simply by their presence. However, their presence also indicates a moisture problem and the likely presence of damaging molds. They are tiny insects, less than 1/8" long, and range in color from clear to light grey or light brown. Most indoor psocids are wingless, looking a bit like a tiny termite.

General Pests

Any household pest may become a pest in a museum. Cockroaches, rodents, silverfish, ants, and other common pests can invade and infest a museum as well as a house or other structure. The biology and ecology of these pests are covered in detail in other modules of this Integrated Pest Management Information Manual, and will not be repeated here.

Monitoring and Thresholds

Regular and scheduled inspections of all specimens on display and all collections in storage can prevent pest infestations from building up undetected. Specimens on display should be checked monthly. All collections in storage should be opened and examined at least twice a year.

Monitors should use a bright flashlight during inspections and look for live adults and larvae and the presence of shed larval skins or feces. The presence of feeding debris or frass around or below specimens is an indication of infestation. So are exit holes, feeding holes, hair falling from fur or pelts, mats of fibers, silken feeding tubes or cases, or moth or beetle pupae. A hand lens can be used to examine for eggs if an infestation is suspected.

Window sills and the inside of ceiling light fixtures should be checked on a regular basis as many pests fly or crawl to light. The immediate display area should also be examined. Pests may be found behind baseboards, under furniture, behind moldings, in cracks in floors, behind radiators, or in air ducts.

Small sticky traps should be placed in hidden areas throughout the facility and inside specimen cases, particularly in high-risk areas. These traps should be checked at each visit, any pests identified and recorded, and the traps replaced as necessary.

Pheromone traps are one of the most valuable new tools for pest management in museums. Pheromones are the natural scents insects use to communicate with each other. Certain pests can be strongly attracted to the traps from the surrounding area, providing an extremely effective early warning system of pest presence.

Pheromone traps are only available for certain insects. Traps useful in museum settings include those for cigarette beetles, drug store beetles, Indianmeal moths, and warehouse beetles (*Trogoderma*). Others are being developed and may be available soon.

Insect electrocutors are useful for detecting and controlling flying insects. They emit ultraviolet light (black light) that attracts flying insects, particularly flies and moths. The insects are drawn into the trap and electrocuted or fall onto a glue board. These traps must be checked and emptied periodically or the dead insects will themselves attract dermestid beetles and other scavengers.

Careful records of inspection results, trap catches, etc. will help identify seasonal risk factors and areas with a high frequency of problems.

The action level will be one live specimen, for most pests in the immediate museum area, because of the sensitivity of museum collections. Presence of live adults or larvae indicate ongoing infestations which should be investigated immediately and treated as necessary. Shed larval skins and feeding damage may have resulted from old infestations, but in regularly monitored collections, these should be regarded as an indication of an active infestation. Thus, it is vitally important to maintain careful monitoring records. All monitoring will be done by the park Curator and additional assigned staff (eg. Museum Technicians).

Non-chemical Management

Pest management in a museum is tricky because without careful management the cure could cause as much damage as the pest. Museum specimens by their nature are rare and valuable. They are often delicate and liable to stain, warp, or simply fall apart if control procedures are too aggressive.
Ideally, the focus of integrated pest management in a museum will be on habitat modification and exclusion to prevent pests rather than on control methods to eliminate them.

Safe and successful museum pest management requires an integrated pest management approach, combining careful and frequent monitoring of pest levels and conditions with a combination of tools, procedures, and strategies. The tactics chosen for a particular pest problem should be adapted to the conditions in a museum. Anticipate the consequences of each tactic. When deciding from among them, choose the combination of tactics least likely to put specimens and visitors at risk.

Nonchemical management tactics include cultural controls (temperature and humidity control, sanitation, lighting), pest-proofing (pest-proof containers or display cases, screening and caulking, etc.), trapping (mechanical, sticky, pheromone, and light traps), vacuuming, freezing or heating infested specimens, and, in rare cases, "radiation" such as microwave ovens and gamma irradiators.

Sanitation plays an important role in the attractiveness to pests of a museum area. Poor sanitation--food debris, grease, loose hairs, and the like--in and around specimens, storage areas, and in cracks and crevices in floors and furniture attracts and holds pests. Good sanitation, particularly regular mopping, washing, and vacuuming, removes potential foods and even newly-arrived foraging pests.

Controlling lighting can also reduce the attractiveness of an area to pests. Minimize exterior lighting. Bright lights shining through doorways and windows can attract insects to the museum area. Light shields, curtains, and closed doors can reduce the numbers of flying insects attracted to the museum.

Temperature and humidity control also can affect pest populations. Lowered humidity and, to a lesser extent, lowered temperatures reduce the chance of infestation and slow down the growth of existing pest populations. For some pests, such as psocids, reducing humidity can be all that is required to eliminate a pest problem.

The most effective way to prevent damage from dermestid beetles, clothes moths, and many other museum pests is to prevent establishment of infestations in the first place. Preparation of specimens should take place in areas other than collection rooms. All incoming specimens should be examined carefully for damage and live insects, and records kept. Incoming specimens showing signs of infestation should be isolated and disinfested. Contact your regional curator before undertaking any control measures on unfamiliar specimens.

Windows in areas where specimens are kept should be tightly screened or kept closed at all times to prevent pest entry. Caulk or otherwise seal cracks and holes in walls and floors, holes around pipes and other utility lines, and other points of pest entry. Install door sweeps where necessary. Air vents and hot air registers can be equipped with filters to trap potential incoming pests. Filters should be changed on a regular basis.

Adult dermestids and other museum pests feed on pollen and nectar, so decorative cut flowers should be kept out of specimen areas to reduce the chance of accidental infestation. Those specimens at high risk of insect damage should be kept in insect-proof cases and examined on a regular basis.

Besides their monitoring function (as mentioned earlier), traps may also be used to control pests. Snap traps and

glue boards are often used against rats and mice. Pheromone traps are also a good supplemental control tactic for certain pests, particularly in removing the last few individuals left in the area. Likewise, insect electrocutors and sticky traps can supplement other control measures.

Some infested museum specimens can be disinfested by freezing them in a large commercial freezer that can reach temperatures of 0^0F or lower. Herbarium specimens, books, mammal and bird collections, as well as various ethnographic materials, have been successfully frozen for insect control. For example, you can kill lyctid beetles by holding the specimens at 0F for at least 48 hours, although four days is preferable. Most other pests can be destroyed by the same regime. Books are commonly disinfested by wrapping them tightly in plastic and freezing them for one to two weeks. Note that freezing poses a significant risk of damage to certain woods, bone, lacquers, some painted surfaces, and leather. Check with your regional curator if in doubt. Low, but above-freezing temperatures, usually 40-42^{o}F, can be used to protect items in storage. The best example is low-temperature storage of furs and costumes.

Small items can be heated in an oven to kill infesting pests. Larger items may require a commercial kiln. Powderpost beetle larvae and eggs will be destroyed if the internal temperature of the wood is held at 120^{o}F for two hours. Holding a specimen at a temperature of 130^{o}F for three hours will kill any insect. However, this level of heat may damage veneers or the finish of specimens, warp lumber, or melt glues. Check with your regional curator if in doubt.

Microwaving as a pest control method is mostly an experimental technique at this time. However, it can be an option as long as the treatment will not damage the item being disinfested**.** For example, microwave ovens have been used to kill cockroaches, silverfish, and psocids inside books. The average infested book is microwaved on high for 20-30 seconds. Longer times risk damage to the glues and bindings of many books.

This method is safe for most hardback books printed after 1950 and high- quality soft-cover books with sewn bindings. Do not use this method on valuable old editions, older books with metallic dyes, inexpensive soft-covers (it will melt the glue), or books bound in leather.

Cedar wood chests are often recommended to protect fabrics from clothes moths and carpet beetles. However, only freshly cut cedar wood is toxic or repellent to fabric pests, and then only in an air-tight container. By the time the wood is two years old, there is no toxic effect left. (Of course, a tightly sealed box of any material will usually keep pests out.)

Chemical Control

Pesticides used in museum pest control are generally some of the same products used for household or other structural pest control. Most pesticide products are not specifically labeled for use in museums. If the product is not so labeled, be sure it is labeled for use in similar sites such as public buildings, institutional settings, etc.

Museums are a good site in which to use nonconventional pesticides such as repellents and insect growth regulators (IGRs) for controlling cockroaches, cigarette beetles, and certain other stored product pests. Cockroach and ant bait stations are an excellent choice for these pests since they pose no risk to museum collections.

When using any pesticide for general pest control (cockroaches, silverfish, ants, etc.), avoid direct treatment of museum specimens whenever possible. Instead, treat cracks and crevices, wall voids, and perhaps the legs of display cases rather than inside the cases themselves.
Paradichlorobenzene and naphthalene are commonly used as repellents in museum cases. They do not eliminate infestations, but may be useful in preventing them. Paradichlorobenzene and naphthalene may cause damage to certain plastics (bakelite, for example), and may soften and shrink resins, adhesives, and paints. Organic gas filters should be installed on the sides of cabinets to absorb fumes and replaced when the odor is detected in the room.

Specimen cases are sometimes treated with insecticidal dusts. This treatment poses some risk of abrasion to specimens stored in the case, and some risk to curators later working with the specimens. Such treatments should be done with care.

If nonchemical treatment of infested materials is not practical, some materials can be treated with standard insecticides. However, in most situations, infested museum specimens should be fumigated. Fumigation is hazardous and it requires professional training to do it safely and effectively. Fumigation of museum specimens is normally conducted in special fumigation chambers, vaults, or "bubbles." Some fumigation is done under tarpaulins. In severe and extensive infestations, an entire building may have to be "tented" and fumigated.

There are a number of different fumigants to choose from. The choice will depend mostly on the objects and materials to be fumigated, since different fumigants are best suited for certain jobs. Some fumigants cannot be used on certain materials because they may react with them (for example, methyl bromide may react with rubber goods). The most commonly used fumigants for museum specimens are methyl bromide, sulfuryl fluoride, ethylene oxide, and carbon dioxide.

Approved Chemical Alternatives at NEPE:

Insect Growth Regulators;
Paradichlorobenzene;
Naphthalene.

Other chemical alternatives that must have prior approval include:

Methyl bromide
Sulfuryl fluoride
Ethylene oxide
Carbon dioxide

Resources

Materials Available

Materials available include common sense items such as doors, screens, display case seals, and basic sanitation supplys and procedures.

Technical Experts

NPS-WASO IPM Coordinator, Columbia Cascades Cluster IPM Coordinator, and/or the Park Curator.

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RATTLESNAKES

Common Name

A number of rattlesnakes occur in North America, but only the western rattlesnake (*Crotalus viridus*) is found in the NEPE area.

Identification and Biology

Rattlesnakes are stout-bodied snakes with heads distinctly wider than the neck. Many are patterned with crossband patterns. Rattlesnakes have retractable, venomous fangs that rapidly swing forward as the mouth opens to strike. Their venom is a mixture of proteins which works to attack muscle activity. Caution must be exercised in handling these reptiles, even those presumed dead.

Rattlesnakes breed in both the spring and fall. They bear from 4 to 25 live young ranging from 6 to 12" long in the late summer and into fall. The young possess venom and are capable of killing prey.
Many rattlesnakes hibernate in well established, communal dens. These dens are most often in holes, caves, or rock crevices where snakes are protected from winter weather. In many of these dens, non-poisonous snakes will hibernate in the same dens.

Rattlesnakes are generally active during the evenings when the temperatures are warm. These snakes have little tolerance for extremely high, daytime temperatures. Where weather temperatures do not reach extremes, rattlesnakes may be active most of the day.

Rattlesnakes will prey on most small animals they can capture, including birds, lizards and mammals.

Natural predators of snakes include mammalian carnivores, owls, and raptors.

Occurrence in the Park

Rattlesnakes may be found in all locations of the park.

Potential Damage and Health Concerns

Rattlesnakes pose no threat to park resources or structures. They are however, a source of concern for human safety. Probably the major area of concern is in the psychological trauma that is sometimes felt. Lethal strikes are uncommon.

Monitoring and Thresholds

If snakes are suspected of being inside buildings, thoroughly examine the exterior of the building to find small cracks and holes where entrance may be gained. Carefully turn over rocks, flat boards, or any other debris that may be lying on the ground. Also, carefully examine interior hiding places that may be used.

A single rattlesnake in a park structure or area of high human activity will be the Action Threshold for Control.

Non_chemical management

The preferred control for poisonous snakes will be capture of the animal and removal from the immediate surroundings or killing them, depending on circumstances. If snakes are released unharmed, release points should be far enough distant and isolated so snakes will not likely come in contact with persons. If release points are not on park property, contact land owners for permission before making releases.

Rattlesnakes in many states are protected by State or Federal law and permits may be required for collection or destruction of problem animals. Check with the state fish and game agency before taking control actions.

Before taking any control measures, make sure you have properly identified the pest. Many non_poisonous, beneficial snake species are often mistaken for rattlesnakes.

Effective fencing that excludes most snakes is one 18 to 36_inches high, made from 1/4_inch mesh hardware cloth, and with the bottom buried several inches in the ground. It is best to place supporting fence posts inside the fenced area so snakes cannot climb them. Gates must fit tightly and the fence must be kept free of weeds or debris.

There are two traps that have proven successful in capturing snakes inside buildings.

- Large glue boards (18-24") may be placed along walls. The snake will crawl onto these and be stuck. To release the reptile outside, pour a small amount of cooking oil on the snake to soften the glue. The snake will then work it's way loose and crawl off on it's own.

- Hardware cloth funnel traps may be placed along walls and captured snakes released outdoors.

Snakes can be also be captured by trained staff with professional, long_handled snake capturing tongs, available from pest control equipment suppliers. Place poisonous snakes in tight, solid-constructed containers with tight locking lids for transportation. Keep the container out of direct sunlight or in areas of excessive cold to maintain body temperature of the snake. Mark containers with warnings so they will not be opened inadvertently.
By maintaining good sanitation around structures (i.e., no debris, garbage, wood piles, etc.), snakes will not be attracted to shade or rodent harborage. Elimination of these areas will minimize the potential for snakes to utilize these areas. Eliminate food and cover by closely mowing lawns and fields.

Chemical Control

There are no toxicants registered for snake control.

Commercial snake repellents have not proven very effective in the past, but one company has recently introduced a new product, Snake_A_Way. No information is available on its effectiveness.
On occasion, poisonous gas fumigation has been required for entire buildings to remove snakes and/or other pests but does not correct the original problem of access. Repellents used against snakes include:

Approved Chemical Alternatives at NEPE:

None

Other chemical alternatives that must have prior approval include:

Mercaptan repellent
Naphthalene and sulfur repellent

Resources

Materials Available

No materials available.

Technical Experts

Contact the local fish and wildlife and or County Extension Agent for the area.

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SILVERFISH

Common Name

The term silverfish is used for the Thysanura and for any of the species within the order. Thysanurans have a distinct carrot shaped body, short legs, long slender antennae and three tail-like appendages (anal cerci) at the end of the body. Silverfish are wingless with scale covered bodies which are about ½" long. Nymphs resemble adults.

There are thirteen species of silverfish (Thysanura) in the United States. Six species are listed which may be pestiferous: they are the firebrat (*Thermobia domestica*, *T. campbelli* (no common name), the silverfish (*Lepisma sacchrina)*, the fourlined silverfish (*Ctenolepisma quadriseriata*), the gray silverfish [also called the giant silverfish] (*C. longicaudata* or *C. urbana* in some texts), and *Acrotelsa collaris* (no common name). (See page 45 of U.S. Department of Health, Education, and Welfare (1967) for pictorial keys to common species and Mallis and Caur (1982) for detailed descriptions of pest species.) Brief descriptions of the habitats and life cycles of the six pest species are listed here.

Identification and Biology

The firebrat is found throughout the world in warm climates. Found indoors in the United States in heated buildings, it is occasionally seen outdoors in the West and Southwest. Firebrats occur around ovens, bakeries, and other warm areas, as they prefer temperatures above 90^0F. Firebrats may become serious pests in bakeries and in areas where starches are stored at warm temperatures, such as in warehouses.

The females deposit eggs in crevices. The number of eggs per batch ranges from 1 to nearly 200, with an average of 50, but stressed females lay fewer eggs. Eggs will hatch in 12-13 days under optimum conditions. Newly hatched nymphs are 1/8" long, white, and scaleless. Development is rapid, with only 1 day spent in the first instar and more time passing between successive instars, although the later instars may last up to two weeks. A firebrat may pass through 45 to 60 instars during its lifetime. The nymphs resemble adults. Females produce one batch of eggs per instar beginning at about the 12th week but can begin to oviposit at six weeks at temperatures of 90-106^{o}F. Firebrats can live up to two years at warm (90-98^{o}F) temperatures.

Firebrats can be killed when exposed to temperatures above 120^{o}F for one hour or more. Temperatures above 112^{o}F and below 32^{o}F kill nymphs. This can be an effective way to manage firebrats if it possible to elevate or reduce temperatures to these levels.

T. campbelli is found indoors in libraries. Little is known about its habits, but its life cycle resembles that of the firebrat.

The silverfish is common indoors on the East Coast, and is also found indoors in the Midwest and Pacific Coast. It is found indoors in warm, humid areas such as basements.

The eggs are deposited in crevices, under objects singly, or in groups of 2 or 3. The female deposits 1-3 eggs per day or at irregular intervals of up to several weeks depending upon availability of food. Eggs hatch in 43 days at 72^{o}F and in 19 days at 90^{o}F. Females may reproduce at 3-4 months of age. Nymphs are 1/8" in size and scaleless when hatched. The first instar lasts 7-10 days; successive instars are 2- 3 weeks long. Scales develop in the third instar. Adults may live up to 3 ½ years, but most live 2 years under favorable conditions (72-80^{o}F, relative humidity of 75%- 97%). Silverfish may pass through up to 59 instars in their lifetimes.

The fourlined silverfish is common on the East and West Coasts and in the Midwest. It lives indoors, often infesting attics, particularly if the roof is made of wooden shingles. It may be found outdoors in summer. Its life cycle is similar to that of the silverfish but not as limited by temperature and moisture.

The Gray silverfish occurs indoors in the South, Midwest, and southern California. It prefers drier areas than common silverfish, such as crawl spaces and attics, but may occur around water pipes in bathrooms. It deposits its

eggs in cracks in groups of 2-20. They hatch in about 60 days at room temperature. The nymphs are scaleless when hatched; scales appear in the fourth instar, and sexual maturity is reached in 2-3 years. This species may live up to 5 years.

A. collaris was recently introduced into Florida, probably from the tropics. Little is known of its life cycle but it may resemble that of silverfish.

Feeding habits of silverfish species are very similar. Once a source of food is located, silverfish remain in the vicinity. Silverfish feed on human foods, especially those containing starch or flour, as well as on paper, especially glaze-coated paper. They eat sizing on paper, as well as glue and paste. They may feed on wallpaper or the paste behind it, causing the wallpaper to become detached from the wall.

Materials such as writing paper, tissue, onion skin paper, and cellophane are preferred, as well as cotton, rayon, and other vegetable textiles. Newsprint, brown wrapping paper, and most cardboard are seldom eaten. Silverfish feed on bound volumes for the paper, the starch and sizing in the bindings, and the linen in some book covers. Stored papers, books, and other printed materials are especially susceptible. Sizing and glue are main attractants, especially if humidity is high. Silverfish seldom feed on wool and other animal based textiles. Cereals may become infested due to the insects' preference for starches and flour. Enzymes and cellulose-digesting bacteria in the gut break down cellulose in paper or other wood products. Silverfish can live for nearly a year without feeding.

Temperature is the most important factor influencing the thysanurans. Low temperatures result in high mortalities, especially among nymphs. Mallis (1982) reports that temperatures below freezing or above 112^{o}F result in 100% mortality in firebrat nymphs. Similar ranges can be expected for other species. Low relative humidities may reduce population growth or eliminate silverfish. In heated buildings, only food availability limits silverfish populations, and their numbers vary little throughout the year. Silverfish may enter buildings by way of boxes, books, or other materials carried inside.

Thysanurans are primarily important as archival pests although they may infest foodstuffs. Individuals are long-lived and reproduction rate is moderate, so populations grow slowly. Large populations can cause severe damage to paper and paper products.

Occurrence in the Park

Silverfish may be found in any park structure if conditions are optimal.

Potential Damage and Health Concerns

Thysanurans are considered primary archival pests. Materials such as writing paper, tissue, onion skin paper, cellophane, bound books, and sizing in bindings. Stored papers, books, and other printed materials are vulnerable targets. Sizing and glue are main attractants, especially if humidity is high. Silverfish seldom feed on wool and other animal based textiles.

Monitoring and Thresholds

Monitoring is best performed by detecting damage caused by silverfish. Book bindings will show minute scrapings. The sizing of paper will be removed in irregular fashion, and the edges of paper will appear notched. In cases of high populations irregular holes will be eaten directly through paper. Other signs of feeding include feces, scales, and small yellow stains.

Active infestations can be detected by observing the small, dark feces, which are visible to the eye as well as scales, which are visible through a hand lens. In addition, feeding activities of silverfish can be observed by coating a piece of paper with a thin layer of flour paste and placing it in an area suspected of harboring silverfish. If silverfish are present, the paper will show small feeding marks.

Two kinds of traps have been used to confirm the presence of silverfish. The first uses a small jar coated with flour

on the inside and tape on the outside to provide a climbing surface. Jars should be placed in areas of suspected silverfish infestations and regularly inspected for silverfish, which will climb in the jar and become trapped. Conventional sticky traps such as those used for monitoring cockroach populations can also be used for detecting silverfish.

The Action Threshold will be based on the amount of damage associated with the silverfish and the confirmation of active infestation by the methods described above. Due to small size and reclusive nature, silverfish are seldom seen. However, their damage can be significant if populations are high.

Non-chemical Management

Warm temperatures and high relative humidities favor most silverfish species. Controlling or eliminating moisture in areas infested with silverfish can reduce populations. Air conditioners or dehumidifiers placed in rooms where documents and books are stored can help to reduce humidity and temperature. Lower temperatures may also slow population growth by reducing rates of development and reproduction in silverfish.

Silverfish found in books and documents can be killed by exposure to microwave radiation. One recommend placing books in a microwave oven for a period of 30 to 60 seconds to kill silverfish. Caution should be used with books or documents containing color plates or in fragile condition.

Sealing cracks and crevices where silverfish hide and breed also reduces populations by reducing suitable habitat. If sealing or caulking is not possible, then cracks and crevices (particularly around bookcases) should be regularly vacuumed to remove silverfish. Good sanitation practices should be followed. All valuable paper products, books, and documents should be placed in tightly sealed containers and cabinets. If this is not possible, access to potential food sources should be limited by removal of food and harborage such as empty cardboard boxes and other waste paper.

There is no information in the literature on natural enemies of the Thysanura.

Chemical Control

Several pesticides are recommended for use on silverfish in Park Service areas. Pesticides for silverfish should be applied in the same manner and with the same thoroughness as for cockroaches. Boric acid should be spread thinly in areas where silverfish are active. Dusts and powder formulations should be applied only in cracks, crevices, attics, and other storage areas where park visitors will not regularly come into contact with the pesticide.

Regularly monitor high risk areas by looking for damage, droppings, scales, or insects or by placing flour paste cards or trap jars. Reduce harborage by enclosing vulnerable materials in insect-proof containers. Reduce relative humidity and raise or lower temperatures to make environmental conditions unfavorable for silverfish.

If a problem arises, evaluate the magnitude of the problem before initiating intervention tactics. After other management options have been considered and implemented, if appropriate, select approved chemical controls that are least disruptive to the environment.

Approved Chemical Alternatives at NEPE:

Allethrin;
Boric acid;
Diatomaceous earth;
Permethrin;
Pyrethrum and pyrethins;
Resmethrin;
Silica aerogel and sillca gel.

Other chemical alternatives that must have prior approval include:

D_phenothrin;
Fenoxycarb (IGR);
Hydramethylnon;
Hydroprene (IGR).

Resources

Materials Available

Materials available include common sense items such as doors, window screens, and basic sanitation procedures.

Technical Experts

NPS-WASO IPM Coordinator, Columbia Cascades Cluster IPM Coordinator, and/or the County Extension Agent for the area.

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SPIDERS

Common Names

Most people are familiar with the general appearance of spiders. Spiders are arachnids, which is a group of animals that also includes mites, ticks, and harvestmen (daddy longlegs). The arachnids are closely related to insects. Spiders, like insects, have a hard external body, but spiders have four pairs of legs while insects have three pairs.

Many people may fear spiders because of misunderstandings concerning their dangerous nature. In reality there are only a few species of spiders that warrant caution. Spiders are a normal and desirable part of the ecosystems in which they occur. They feed on other insects, including species which are pests of plants and nuisance species such as biting flies, as well as other spiders and scorpions. Therefore, spiders are generally considered to be beneficial organisms.

Despite the generally benign nature of most spiders, bites or stings by some species can be life-threatening to small children, the elderly, or people who are hypersensitive. There are three spider groups of medical importance: the widow spiders (including the black widow, *Latrodectus mactans*), the brown recluse spider, *Loxosceles reclusa* (and the related *Loxosceles laeta*), and the aggressive house spiders (genus *Tegenaria*). None of these dangerous species of spiders bite or sting humans without provocation. The majority of bites or stings occur because the spider has been sat, rolled, or stepped on, or because attempts were made to pick up the spider.

Identification and Biology

<u>The Brown Recluse Spider</u>

The brown recluse spider, *Loxosceles reclusa*, and a related species, *L. laeta,* are also commonly referred to as violin or fiddleback spiders because they have a dark fiddle shaped pattern on their upper body. They vary in color from tan to dark brown. A second identifying characteristic of the brown recluse spider is the presence of only three pairs of eyes. (Most spiders have eight.)

The brown recluse spider is sedentary and builds an irregular web that is often not recognized as a spider web. Females lay eggs in flattened egg sacs that are frequently attached to the underside of objects. Mating in this species occurs from February to September. Up to 40 spiderlings may hatch from a single egg sac. A single female may produce up to five egg sacs in a summer. Females can live up to four years, males less.

Indoors, the brown recluse can usually be found in infrequently disturbed areas away from light sources, such as behind pictures, beneath or behind furniture, in boxes, in clothing, among stored papers, between the corrugation of boxes, and under food sacks.

The natural habitat of the brown recluse includes the underside of rocks, loose bark, and crevices in decaying logs. However, many outdoor refugia provided by the activities of man are frequently inhabited by the brown recluse spider.

The brown recluse spider occurs in a region roughly delineated to the north by the northern boundary of Illinois, to the west by the western boundary of Kansas and Oklahoma, and to the east by Tennessee. Additionally, single specimens of the brown recluse, presumably artificially transported to these areas, have been reported from Washington D.C., Arizona, California, Florida, New Jersey, North Carolina, Pennsylvania, and Wyoming. *L. laeta* , native to South America, has also been reported in the United States in Massachusetts and California. Both of these reports of *L. laeta* indicate that it has been transported into the United States by people. It is unlikely that *L. laeta* has become established in the United States, but it may be an occasional problem in areas where products are frequently shipped from South America.

<u>The Widow Spiders</u>

There are five species of widow spiders (*Latrodectus*) in the United States. The combined geographic range of these spiders encompasses the entire United States. Three of these species can generally be considered to be "black widows." Females of all of these species are metallic black with reddish marks commonly forming an hourglass shape on the underside of their thorax. The most well-known species, the common black widow spider, *Latrodectus mactans* occurs from southern New England to the southern United States The Northern widow, *L. variolus* , occurs from the mid- Atlantic states north to Canada. The western widow, *L. hesperus*, occurs west of the Rocky Mountains. Two additional species, the brown widow, *L. geometricus*, and the red widow, *L. bishopi*, are tropical species whose United States distribution is restricted to southern Florida. *Latrodectus geometricus* is another introduced species that primarily occurs in domestic situations, but its distribution is sporadic.

Widow spiders are cobweb builders; a typical web of a widow spider is a small, tangled maze of coarse fibers that are made in dark corners or crevices. Frequently these webs are made near ground level. These webs may not even be recognizable as an active spider web. Eggs of the widow spiders are laid in sacs of silk within the female's web. A single egg sac may contain up to 400 eggs. The eggs of widow spiders hatch in three to four weeks. The hatchlings are highly cannibalistic and therefore most of the young will be consumed by their brothers and sisters. Web- spinning spiders such as the widow spiders are not active outside of their webs. This is especially true of the western widow spider which creates webs primarily in cracks and crevices.

Aggressive House Spiders

The aggressive house spiders are in the genus *Tegenaria*. Only one native species, *Tegenaria chiricahuae*, occurs in the United States, but at least six introduced species of *Tegenaria* now occur in the United States. These spiders as a group are often referred to as funnel-web spiders. They build funnel shaped webs in dark, moist areas such as basements and crawl spaces, and sit in these webs and wait for prey to walk by. Generally, these spiders are yellow to pale tan in color with long legs. These spiders occur in highest frequency in July through September and reproduce during this period. Females produce an egg sac that is placed near the opening of the funnel in their webs. Eggs hatch the following spring.

Although the bite of these species is not considered to be as dangerous as that of either the brown recluse or widow spiders, it can cause a similar ulceration of the skin as the brown recluse and may involve systemic reactions. The species that cause the worst bite reactions are found in the northwestern United States; *Tegenaria agrestis* occurs from Idaho to Vancouver and Winnipeg in Canada. It builds a web at or near ground level, and rarely climbs up vertical surfaces. This spider is called an aggressive house spider because it will bite with little provocation if cornered or threatened. This may be related to their hunting strategy and may increase the likelihood that humans will be bitten by these spiders.

Occurrence in the Park

Spiders may be found in all areas of the park.

Potential Damage and Health Concerns

Although black widow and brown recluse spiders can be harmful to man, other kinds of spiders should be regarded as beneficial predators on insects.

Black widow spider. The severity of a black widow spider bite depends on the amount of venom injected, the age and condition of both the victim and the spider, the part of the body bitten, the degree of immunity of the victim, and the treatment given. Bites are rarely fatal in strong, healthy adults but young children and elderly can be vulnerable. Persons with high blood pressure may be at risk of a stroke if bitten.

Brown recluse spider bites are not painful at first and are rarely lethal but do cause severe tissue breakdown which results in long_lived wounds and festering sores. Secondary infection after a brown recluse spider bite always presents a potential for gangrene; skin grafts are sometimes required to close brown recluse spider wounds.

If bitten by a spider, carefully capture it in a bottle, add a little alcohol, and take it to a specialist for identification.

Inspection and monitoring

Recluse, widows, and many other spiders are nocturnal. Schedule inspections for nighttime and use a flashlight. Look for silky egg cases about 1 /3 inch in diameter, loose irregular webs, or cast skins. The cast skin of a brown recluse spider is fragile but the characteristic violin markings remain on the cephalo_thorax portion.
Sites to check during inspection are areas of little use, such as, closets, attics, small crevices, and wood piles.

Sticky traps are an effective device for monitoring.

The Action Threshold for these spiders is their presence indoors.

Non-chemical Control

Sanitation and habitat modification are key tactics for control of spiders indoors. This includes vacuuming in corners, window sills, and attic areas, and keeping premises free of unneeded, unwanted items such as undisturbed clothing, papers, and other litter. Indoor habitat modification that creates a barrier to the movement of spiders into buildings is also a key tactic to effective spider control.

Sanitation is one of the key methods of controlling spiders in buildings. The corners and crawl spaces of buildings should be kept free of spider webs. This may be accomplished by simply dusting these areas or by using a vacuum to remove existing webs. Vacuuming removes active spider webs, adult spiders, and spider egg sacs. Living spiders will desiccate quickly in the vacuum bag, but depending on the design of the vacuum, it may be useful to empty the bag immediately after use in order to prevent the spiders' escape. Removing litter such as newspaper and wood from the interior and the sides of buildings is also crucial for effective elimination of spiders. In addition to sanitation, creating a physical barrier to movement of spiders into buildings is also an effective management technique. Pruning shrubbery and other plants away from buildings will also limit the access of spiders to buildings.

Barriers also limit access of buildings to spiders. Caulking, repairing screens, and filling cracks and crevices around windows, doors, and foundations with materials such as expanding polyurethane foam will exclude many spiders from buildings. Common areas to inspect for holes and gaps include entry holes for plumbing and electrical lines, and window and door casings. Window and door screens should be repaired to fill in holes large enough for entry of spiders. Gaps in the wall boards and ceiling-wall interfaces should be closed, and door and window casings should be filled with caulking or a foam insulation material. Foam insulation material can also be used to fill wall voids and crawl spaces if spiders come in through these areas. Spiders can easily gain access to buildings through gaps beneath doors. Placing a piece of weather stripping under a door so that there is no gap between the bottom of the door and the floor when the door is closed will alleviate this problem.

If crawl spaces are a breeding area for spiders, the reason is usually excess moisture. By eliminating moisture from crawl spaces, spiders can be eliminated. Placing plastic ground cover over bare soil can eliminate moisture in some areas, such as beneath cabins. The key to many moisture problems is to increase venting. Therefore, opening up foundation vents under a foundation may eliminate moisture from a crawl space, without allowing increased access of the building for spiders.

Additional precautionary measures which may reduce the risk of being bitten by spiders include wearing shoes at all times, using leather gloves when moving rocks, wood or other debris, and shaking out sleeping bags and clothing before using them.

Chemical Control

Chemical control of spiders inside of buildings is not recommended and should be considered only as a last resort. Residual sprays are not recommended for use in buildings that are occupied, or are to be occupied in the near future. If residual materials are used in buildings not currently occupied or in areas where other methods fail, applications are recommended only along baseboards, door casements, and corners, and only where spiders are present. Apply silica aerogel, boric acid, or resmethrin into cracks and crevices of interior baseboards, door casements, corners, and

other area where spiders have been observed. Similar treatments can be made in attics and crawlspaces, particularly in areas of high moisture (bathrooms, kitchens, hose bibs, etc.) In dry areas, residual dusts are more effective. Natural pyrethrins are not very effective on spiders.

Chemical control using a long-lasting residual pesticide can be effective in controlling populations of spiders outdoors. Many residual materials are registered for control of spiders. Problem outdoor areas usually needing treatment include porches, garages, eaves of the roof, crawl spaces, and other areas beneath buildings.

Pesticides are effective on spiders when directly applied to the pest, but pesticides are not normally used for spider control because of difficulties in getting chemicals into secluded spider harborage. Also, spiders do not pick up pesticides very well (they walk on hairs on their feet and do not directly contact surfaces), they do not ingest pesticides during grooming, and they live in webs which are above and rarely contact surfaces treated with residual chemicals.

Schedule follow_up inspections for 2 or more weeks after treatment, monitor the results, and retreat, where necessary.

Approved Chemical Alternatives at NEPE:

Boric acid dusts for cracks and crevices;
Diatomaceous earth as a dust or dust with pyrethrins;
Hypochlorite (household bleach) sanitizer;
Pyrethrum (synergized with piperonyl butoxide) contact sprays ;
Resmethrin aerosols space treatments;
Silica aerogel or silica aerogel with pyrenone for dusting cracks and crevices.

Other chemical alternatives that must have prior approval include:

Allethrin (with piperonyl butoxide) aerosol space treatments ;
Carbaryl dust for outside pests;
Diazinon for outdoor pests;
Malathion for outdoor pests.

First Aid

For any bite or sting it is important to reduce stress and help the inflicted person to relax. There is evidence that this will reduce the toxic effects of some bites and stings. An ice cube may be applied for a short time to reduce the pain at the site of the bite or sting; this does not reduce the effect of the bite, but may make the afflicted person more comfortable. (DO NOT IMMERSE THE WHOLE LIMB IN WATER.) If in doubt about the seriousness of a bite or sting, or if a person is bitten or stung by any of the medically important species discussed in this module, contact your local poison control center or a physician immediately. Also, collect the scorpion or spider in question if possible to assist in the treatment of the sting. For further discussion of medical treatment and the progress of envenomation by scorpions, or spiders, see Smith 1982, Ebeling 1975, or Polis 1990 for treatment of scorpion envenomation.

The sting of most scorpion species and the bite of most spider species are not considered to be dangerous. However, if a person is stung by a scorpion in an area in which the bark scorpion occurs medical attention should always be sought since its sting may be. Additionally, any bite or sting may elicit an unusual allergic reaction by persons who are hypersensitive to the bite of a specific species. For this reason all bites must be examined to ensure the safety of those involved. A hyperallergic reaction can lead to anaphylactic shock and in very severe cases, respiratory distress may develop. It is not unusual for a person to have some pain and numbness in the same region as the site of the bite. However, if, for instance, a person is bitten on their hand and their legs begin to swell, this is indicative of a systemic reaction, and this person should receive medical attention as soon as possible. People who are known to be hypersensitive to other stinging insects such as bees and wasps are not necessarily hypersensitive to spider bites or scorpion stings. Likewise, each spider or scorpion has a very specific type of venom and a person may be sensitive

to the venom of one species and not sensitive to the venom of a closely- related species. Lastly, some anti-venoms are available for treatment of some bites and stings, but their availability is variable. Contact your local poison control center for information regarding anti-venoms if dangerous spiders or scorpions are a problem in your region.

Resources

Materials Available

Materials available include common sense items such as doors, window screens, and basic sanitation procedures.

Technical Experts

NPS-WASO IPM Coordinator, Columbia Cascades Cluster IPM Coordinator, and/or the County Extension Agent for the area.

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STINGING INSECTS (Bees, Wasps, Hornets, and Yellowjackets)

Common Names

A variety of stinging Hymenopteran insect pests commonly occur throughout the country and include both social and solitary insects. Honey bees (*Apis mellifera*), yellowjackets (*Vespula spp., Dolichovespula spp., Vespa spp.*), bumble bees (*Bombus spp*.), paper wasps (umbrella wasps; *Polistes spp.*), and bald faced hornets (*Dolichovespula maculata*) are social insects.

Mud daubers (Subfamilies Trypoxyloninae and Sphecinae), digger wasps (*Scolia spp*. and *Campsomeris spp*.), and carpenter bees (*Xylocopa spp*.) are solitary hymenopterans.

Identification and Biology

Social hymenopterans live in colonies and are responsible for most stinging incidents, whereas solitary bees and wasps seldom sting people and are usually not aggressive.

Honey bees exhibit a range of color from yellow, to black and brown. They are about 2/3" long, with light colored hairs covering their body, and a pollen sack on the hind legs.

Honey bees show elaborate social divisions in the nest and construct uncovered/open combs in sheltered sites (holes in walls, trees, rocks, buildings, or under rock overhangs, or in structural voids). Their nests may contain 60,000 to 80,000 individuals at full strength. The European (often, domestic) honey bee is still the more common honey bee over most of the United States, and is not particularly aggressive or defensive of its nest. The European honey bee, however, is very susceptible to virola and tracheal mites which have recently appeared and are killing many bee colonies. The numbers of honey bees seasonally found in dry desert areas can vary by 10 or more times, depending on annual rainfall patterns.

Africanized honey bee (AHB) are less susceptible to virola and tracheal mites than European honey bees, are less selective of a location for a nest site, and much more aggressively defend their nest. AHB will place nests in the same locations as do European honey bees but will also use holes in the ground, culverts, pipes, covered water meters, overturned flower pots, etc.

Bumble bees are closely related to honey bees but are larger (about 1_inch long), robust, social, black and yellow colored bees with a hairy abdomen. The abundance of hair on the top of the abdomen and color readily distinguishes bumble bees from similar_sized shiny black carpenter bees.

Only fertilized queens over_winter. In early spring, they build a nest in a hole in the ground and provision it with pollen and nectar. When the eggs hatch, young become workers assist the female in enlarging the nest which, by the end of summer, may contain up to 400 worker bees. Male and female bumble bees capable of reproducing are produced during late summer; they leave the nest, mate, enter hibernation, and become active during the following season.
Solitary bees belong to one of a number of different families which contain numerous genera and species. Some solitary bees include insects like yellow_faced bees (Family Colletidae), green metallic bees (Family Halictidae), mining or digger bees (Family Andrenidae, Subfamily Anthrophoridae) clarkia bee (Family Melittidae) leafcutting bees (Family Megachilidae), mason bees (Family Megachilidae), and sweat bees (Family Halictidae). Insects from the different families are best identified by a specialist who is able to compare subtle differences in wing venation. Identification to the genus and species level can be quite complex.

Life cycles of solitary bees may be very complicated and differ greatly among various families and genera. In general, solitary bees feed on nectar and the females provision their larvae with nectar and pollen during egg laying. Some species are very specific as to the kind of flowers they use. Some species may become exceptionally numerous in a relatively small area only when certain cacti or flowers are available.

A female solitary bee usually digs a simple nesting burrow or series of branching burrows (some species dig

burrows communally) a few inches deep in the soil, pithy stems, dead wood, or constructs a nest cell of clay (mason bees).

Some species prefer to nest together in large numbers in specific soil types, such as the sides of a clay or sand embankment (Anthophora) and sometimes dig burrows into archeological adobe ruins. Other species prefer to build burrows in meadows, gardens, and lawns; still others prefer to build burrows in abandoned fields, or ~are soil. The female places nectar and pollen in the completed burrow, lays an egg(s), and closes the burrow. Larvae mature within a month or so and emerge as adults. The life history of many of these bees is still not fully known but many solitary bees are highly beneficial insects because they pollinate plants.

Paper wasps are red or dark brown in color and can be identified by their long, rear legs which hang down and trail during flight. Paper wasps are attracted to warmth and often place their nests under building eaves and in other locations that are protected from light and weather. Nests are single_combed, umbrella_shaped, flat and are not covered with an exterior, protective, paper_like envelope like hornet nests. The nests (which may be basketball_size or larger) are found in cool and protected places from late_May to early June when day and night temperatures are warm. At maximum size, nests usually contain less than 250 insects, are readily visible, and are normally attached under overhangs. Paper wasps are not normally aggressive except when they feel the need to protect the nest. Aggressive behavior, however, tends to increase during late season when most human stinging incidents occur.

Yellow jackets are 1 /2_inch or more long and distinguished from other social wasps by their distinctive coloration of alternating yellow and black bands (some species may show white or red colors) and their nests are always built in protected places (abandoned rodent burrows, decayed tree stumps, and holes in buildings). The nests reach maximum size (3,000 to 10,000 workers) by late July to late September. Yellow jackets are extremely aggressive.

Bald faced hornets are much larger (to 3/4_inch long) and huskier wasps than yellow jackets. They are mostly black with indistinct whitish stripes on the body and a whitish face. Hornets are normally not aggressive unless their nest is threatened. The nests are usually placed in areas exposed to the elements and commonly found under structural roofs or in vegetation. The nests are typically pear_shaped, the larger end being at the top, and are covered with an outer sheath. Nests may only contain 100 to 700 workers.

Mud dauber wasps. Mud daubers are solitary wasps and are identified by their long, slender shape (½ to 1_inches long), very long and slender abdomen, and dark blue or black color with pale markings and metallic luster. These wasps build tube_like mud brood chambers in sheltered places inside garages, sheds, or under eaves and porches. People often fear mud daubers because of their resemblance to paper wasps; but, mud daubers do not defend their nest and rarely sting. Mud daubers are beneficial because they eliminate spiders and insect pests found around structures.

Digger wasps are long, robust, hairy wasps with light colored bands and areas of red and yellow. They have a 1_inch wide wingspan and appear during early mornings when they may be seen flying over and digging holes in lawns while searching for or covering up beetle grub prey. The female stings a beetle larva, constructs a cell around it, and lays an egg on the larva. The lone, developing wasp larva feeds on the beetle larva and overwinters in the burrow as a pupa. Tarantula hawks (*Pepsis formosa*) are identified by their blue or black bodies; black, blue, red, yellowish, or orange_colored wings, and size (1 to 1_3/4 inches long). They show erratic movements, darting into and out of cover and by constant wing twitching. Tarantula hawks prey on tarantulas and are usually seen flying close to the ground looking for prey.

Carpenter bees are large (1 /2 to 1_inch long), shiny black, solitary bees that are sometimes seen slowly flying around wooden moldings or beams or entering holes in wood. Females excavate a 4 to 6_inch long egg gallery in wood where she lays eggs and provisions the burrow with food for the larvae. Young emerge in early summer.

Life histories and habits of wasps and bees vary considerably. Although honey bee colonies may use a nest site for a long time (up to 30 years), bumble bees, wasps, hornets, and yellow jackets construct new nests each year. All these insects opportunistically use holes in structures or rocks as nesting sites.

Foods and Feeding: Many social wasps prey on small insects (flies, caterpillars and beetles) which they feed to

larvae. Adult wasps feed on carbohydrates or sugars (flower nectar, tree sap, fruits, honey dew, etc.) but also scavenge human foods from gar~age cans. In general, solitary wasps prey on spiders and insects.

Honey bees and bumble bees feed on flower nectar, pollen, and honeydew and are sometimes attracted to garbage. Most solitary bees feed on nectar and pollen.

A number of birds prey on honey bees and wasps. Skunks can seriously damage honey bee colonies.

Occurrence in the park

Bees, wasps, yellow jackets, and similar insects are native species and occur throughout the park. They are attracted to flowering plants, heavy vegetation, disturbed soil, poor grade around structures, garbage cans, and water leaks. Paper wasps and yellow Jackets can be found anywhere in the parks but become common pests when they establish nests around residences, in water control boxes in the ground, and under buildings.

Potential damage and health concerns

Female bees and wasps will only sting to protect the nest or young and males do not sting at all. Very few stinging incidents occur when honey bee swarms formed after nest division) are found hanging on trees or buildings.

Human stinging incidents are usually worse during rainy seasons and during late_summer to fall when nests are more vulnerable. However, both visitors and employees can accidentally disturb bee and wasp nests located in the ground, on vegetation or structures, or close to trails and visitor_use facilities. These nests continually pose various degrees of hazard. Stings are very painful and some people are so afraid of being stung they may injure themselves (or cause an automobile accident) trying to escape flying bees and wasps. A given percentage of people are highly allergic to stinging insects and become very ill or die from only a single sting.

Wasps and bees are seldom responsible for direct structural damage; however, when nests become established inside of building walls, entire sections of the wall may have to be removed to extract colonies or abandoned nests. Predators (including woodpeckers) often subsequently cause direct and serious damage to walls when trying to reach insect combs or larvae.

Yellow jacket problems often seem to appear almost overnight during late summer (after July) when the size of insect populations and activity peak, usually after the first frost and when prey items or food are no longer available. Yellow jackets are very aggressive insects, especially when protecting the nest. The act of stinging in most bees and wasps causes release of airborne aggression pheromones (odors) that further enrage the colony. Unlike honey bees, wasps do not have a barbed stinger and an individual can sting a number of times. Nests may be located in holes/voids in buildings, bushes, under eaves, etc. but are also found in the ground or in the roots of dead/rotten trees.

Paper wasps nest are commonly located under building eaves and in other partially_hidden locations where people may inadvertently come into close contact with the insects and be stung. During fall, some species of male paper wasps fly to the highest available and preferred site for mating (i.e. towers, buildings, etc.) where they attract females with sex attractants (pheromones). Groups of females arrive, find males, mate, and hibernate in the sites chosen by males. Such aggregations of wasps sometimes occurs in locations where people come into contact with the insects and are stung. Bald faced hornets seldom impact people because nests are usually located high up in trees/shrubs. Hornets, however, can be very aggressive should their nest be disturbed. Nests on buildings, in low shrubs, and sheds always Pose hazards to persons passing by.

Currently, honey bees of the European genotype do not pose serious hazard to visitors. Although honey bee venom is relatively toxic to man and a number of persons are highly allergic to it, honey bee aggressiveness is confined to nest protection, they do not protect their nest out very far (usually, out to a distance of 10 to 20 yards), and relatively small workers respond to disturbances. However, honey bee aggressiveness tends to increase when temperatures are lower than 56_F.

The AHB is much more defensive of its nest and may protect it out to a distance of 150 or more yards. And, ten or

more times as many AHB workers will respond to disturbances than do European honey bees. Various persons in Central America who initially survived a serious AHB attack have been reported to die within a year or two following the attack because of kidney and liver problems. AHB are not yet known in the park but could, in the future, pose threats to humans should nests become established near visitor use areas.

Some solitary bees damage adobe walls, soft wood, and foam roofs when excavating nesting burrows. *Lithurae apicalis*, Family Megachilidae, a common leaf_cutter bee over much of northern New Mexico is one of these and nests in decaying or rotting wood (i.e. damaged portions of roofs, etc.). Larvae developing in the burrows subsequently attract woodpeckers which may do extensive damage. Various species of solitary bees such as digger bees (*Anthophora spp*.), alkali bees (*Nomia nevadensiangelis*) and virescent green metallibees (*Agapostemon virescens*) and the greatgolden diggerwasp (*Spex ichneumoneus*) prefer to nest in soil and clay bands and sometimes may dig nests burrows in archeological adobe walls

Other solitary bees may dig nests in trails and frighten visitors using trails. Solitary bees are not normally known to be aggressive and leaf-cutter and most other solitary bees only sting when a victim touches the bee (while brushing the bee off) or has come into the line of travel of bees flying to/from the nest. The pain from stings of most solitary bees is usually mild. Approaching a nesting aggregation of digger bees, however, may result in very painful stings.

Very few people are stung by bumble bees; however, bumble bees will actively defend a nest which can be well_hidden in the ground and not easily detected until stepped on. Bumble bees do not have barbed stingers and can repeatedly sting. Persons disturbing a nest can receive a rather large number of stings and the bees will chase people for a distance of 300 or more yards. Although bumble bee stings are painful and the bees are fearful because of their size and noise, relatively fewer bumble bees are present in any given nest to attack a person than are present in honey bee and wasp nests.

The presence of mud dauber brood chambers are undesirable and cause damage to painted/ finished structural surfaces. And, abandoned brood chambers attract carpet beetle infestations.

Digger wasp do not attack people and rarely sting. Persons have been known to safely walk among them as they fly over lawns.
Tarantula hawks are beneficial insects but will sting if provoked; great care should be used around them since the sting can be violently painful.

Carpenter bee holes can seriously damage decorative structural wood members and developing larvae in the galleries may attract woodpeckers. Damage by woodpeckers can be even more serious than that caused by the bees. The female carpenter bee rarely stings; male carpenter bees do not sting.

Monitoring and Thresholds

Inspections for honey bees and other stinging insects will determine the presence and kind of insects, locations of nest sites and available harborage, relative abundance, and structural deficiencies or habitat conditions supporting or attracting the pests.

Watch for bees and wasps that may be entering holes and cracks in structures. Sometimes wasp and bee nests inside of walls can be located by use of a stethoscope.

Watch for honey bees within a 3 mile radius of open water sources. Most worker bees only fly ½ to 1 mile from the nest to water but some may fly as far as 3 miles. The maximum foraging distance for honey bees is about 6 to 8 miles.

Develop an ability to follow flying bees from flowers or water to their nest. If bees cannot be followed, triangulate two or more compass azimuths from different locations.

Periodically through the season, monitor the number, relative size, and aggressiveness of paper wasp, yellow jacket, hornet, and honey bee colonies. Closely watch honey bee colonies for any sudden or unusual changes in aggressive

behavior which could indicate "Africanized" traits. Inspect for and monitor for sensitive areas where AHB could establish colonies. AHB more readily nest in the ground, pipes, holes, etc. than do European honey bees.

Suspected sudden increases in the numbers of bees present during any given season or year are best tested when 3 or more years of base_line data are had. Compare suspected unusual number of bees present with previous, average numbers. Base_line information on the numbers of bees present during specific seasons can also be developed with random transect counts of individual foraging bees on flowers. Maintain records of the numbers, times, and locations of honey bee swarms.

Active paper wasp, hornet, yellow jacket, honey bee, or solitary bee nests will be removed or controlled when located close to areas of high use or otherwise pose threats to visitors or employees or when damaging resources.

Immediate control action will be undertaken for severe yellow jacket problems, when 10 or more yellow jacket foragers visit an open garbage can with 10 minutes. Changes in this threshold may be made after records of yellow jacket visits are correlated with the numbers of reported stinging incidents.
Any carpenter bee activity seen in or near buildings or historical structures will be the action threshold for corrective and/or preventative control measures.

Non_chemical management

Thoroughly seal all cracks and holes 1 /8_inch or diameter that lead into voids in residences, garages, outbuildings, crawlspaces, etc.

Coat foam roofs with a thick, white coating to cover cracked or blistered areas on old roofs. Fans or air curtains can be used to control flying insects.

Habitat in visitor_use areas highly attractive to nesting solitary bees can be covered with plastic during the short nesting period.

Repair and control all water leaks; bees must have water to survive. Remove unnecessary sources of open water. The numbers of bee colonies present in an area can become quite large (10 or more times normal) when water is available to them.

Keep areas clean; remove or tightly cover empty containers, pipes, and culverts; remove any old or abandoned bee equipment (colony boxes); exclude bees from trash containers and frequently wash garbage cans; remove attracting food materials (rotting fruit, cold drink cups); remove piles dead limbs and other vegetation; cover stacks of pipe and lumber; modify open picnic and outdoor tables and chairs so as to not expose open pipe ends.

Residents need to tie up household garbage tightly in plastic bags before placing it in collection cans.

Remove all debris, piles of lumber piles, or other potential nest sites from around buildings and areas of human use. Prune palm fronds and other thick vegetative growth that may harbor nests.

Remove all needless sources of open water (faucet drips, leaking pipes, etc.) which attract honey bees (they use water to cool their nest) and wasps. Do not inadvertently loose soil or depressions (as, water catchments on trails) to attract bees and wasps.

Study the habits of solitary bees and modify their preferred nesting locations by wetting the soil if insects are attracted to dry locations, covering compacted or hard soil with sand or other species, or paving trails with soil_cement materials.

Controls taken against the nests of most stinging insects are best done at night when the insects are not active. Scout the nests by day to reduce the needs for illuminating the colony at night with a flashlight, light tends to aggravate the insects. If a light must be used at night, illuminate the nest from the rear to prevent disturbing the colony and so insects will not be attracted to the light. After removing a nest, carefully clean any attracting odors and pheromones

from the site (soap, ammonia, etc.) to keep insects from returning.
Various possible non_chemical controls include:

- Soapy water spray (from 1 to 4 parts dish detergent in 4 to 16 parts water) removes the waxy coating from an insect's body and the reduced water surface tension drowns insects. Use a strong stream of soapy water from a high-pressure pumper to destroy the combs of honey bees and kill the insects.

- Carbon dioxide foam fire extinguishers, large vacuum cleaners, hot air, and agricultural flamers have been used to destroy stinging insects nests, depending on site location and local conditions.

- Hymenopterous insects are easily killed by heat. Cover a hornet nest or a swarming honey bee colony with a plastic tarp and then expose the tarp to intense sunlight to cause a build up of heat.

- Large, shop vacuums can be used to catch and remove colonies and swarms.

Attempts to lessen wasp problems in the spring_time by reducing the numbers of insects present in during fall are not effective (natural rates of over_winter mortality for fertilized queens are likely around 99.9 percent). Focus control efforts during the springtime when queens can be attracted to pollen and nectar traps.

Other non_chemical control of wasp numbers in an area might include the following:

_ All beverages sold by concessionaires for take_out should be supplied with a plastic lid and straw.

_ Move dumpsters and trash barrels away from doorways and other high traffic areas. Fit dumpsters and trash barrels with tightly closing lids. Frequently pick garbage up, continually check cans for gaps and holes and keep cans clean. Use garbage liners.

_ Remove stumps, dead limbs, hollow trees that serve as potential nesting sites.

_ Remove plants that attract wasps and bees including those vulnerable to scale or aphid attack (indicating a source of honeydew).

_ Traps: use sticky traps or jar traps baited with meat or sweets for wasps.

Capture bee swarms by placing an open cardboard box under a limb supporting the swarm. Make 3 cuts in one side of the box and fold the flap out so as to make a door with a ~landing pad". Strike the limb supporting the bees sharply with a stick so the bees will fall into the box. Cover the box and move back from the site to allow any flying bees to enter the box through the prepared door. When it is dark, close the box and remove it. Bees in an enclosed container can easily be killed by placing the container in strong sunlight.

Kill (by swatting) any carpenter bees seen burrowing into wooden structural members. Keep holes in structures plugged and painted so as to not be attractive to female carpenter bees.

AHB may swarm 3 or more times during a season and migratory swarms can fly 10 miles before settling down into a nest. Swarming bees are usually relatively gentle; however, keep people away from AHB swarms and only collect swarms at night when the entire colony is settled. Never try to remove swarms alone; always have 2 or more trained professionals present when monitoring or controlling AHB colonies. Never allow spectators near AHB operations.

Chemical Control

Diluted ammonia, sometimes used as a disinfectant in trash cans, dumpsters, outdoor tables, etc., is said to also repel wasps and bees. Beekeeper supply houses sell foul_smelling chemicals used by beekeepers to drive bees out of hive boxes before harvesting honey.

Aerial wasp and hornet nests and combs (in trees, under eaves, etc.) are effectively treated with aerosol wasp "freeze" spray but some sprays are not very effective on honey bees. Honeybees are susceptible to resmethrin which chemically combines with combs and prevents future re_establishment. Regardless of the product used, always have a second, back_up container available. Other chemical options, that may or may not be approved, depending on circumstance, include: dichlorifos, diazinon, carbaryl; acephate, chlorpyrifos, and bendiocarb.

Some agencies are experimenting with a slow_acting poison (acephate) to destroy AHB colonies. Bees are attracted to a sweet bait and then the bait is amended with poison. Acephate used for this purpose is only available under a special, experimental label for honey bees. Extreme care must be taken to not affect non_target, European honey bees (domestic) or other organisms.

Locate bumble bee nest site and inject the nest with a resmethrin spray and follow up with residual dusts. If nest entrance cannot be located, spray the area suspected to contain the nest with wettable insecticide powder to help prevent your being stung while looking for the actual entrance hole. If bumble bees are nesting in a wall void or attic, use the same chemical treatments as for honey bees in wall voids or attics.

Hornet nests have only one entrance on the bottom. Treat nests by spraying a chemical pesticide directly into the entrance hole to kill the guard insects. After treating the entrance, treat the nest interior with a desiccant or pesticidal dust (bulb duster with a 12_inch extension wand). Leave the nest in place for 24 hours to assure all returning worker wasps are killed. Treat the nest again should the nest remain active. Pyrethrin and aerosol "freeze" chemicals provide quick knockdown and residual control for hornets.

Treat the area surrounding an entrance of wasp and yellow jacket nests in structural voids with resmethrin to disorient insects. Then, insert a treatment tube into the nest and thoroughly apply residual pesticide dusts or aerosols. Plug the nest entrance with steel wool and dust the area surrounding the plug with residual pesticide to kill any returning workers. If the entrance hole being used by the wasps can not be found, use a stethoscope to listen through the wall for nest activity and drill a hole through the wall and inject pesticide aerosol or dust directly into the colony.

Inject residual pesticide dusts or sprays into carpenter bee burrows to kill the larvae and then seal the hole with a pesticide_impregnated plug or caulking. Paint over caulked burrows to keep from attracting other carpenter bees.

Destroy all colonies of aggressive wasps, hornets, yellow jackets, bees, or other stinging insects which could possibly endanger the public or employees with physical or mechanical means (heat, vacuum, freezing, etc.) or with properly approved pesticides.

Approved Chemical Alternatives at NEPE:

Allethrin (with piperonyl butoxide) aerosol space treatments for flying insects;
Boric acid dusts for cracks and crevices;
Resmethrin aerosols and dusts for space treatments; outside applications;
Silica aerogel for dusting cracks and crevices and along pathways used by pests;
Silica gel with pyrenone for cracks and crevices;
Wasp freeze chemicals (without CFC's) for wasps.

Other chemical alternatives that must have prior approval include:

Carbaryl dust for outside pests (carpenter bees);
Diazinon for outdoor pests ;
Malathion for outdoor pests;
Potassium salts of fatty acids (soaps) for bee colonies, insects on plants.

Resources

Materials Available

Materials available include common sense items such as doors, window screens, and basic sanitation procedures.

Technical Experts

NPS-WASO IPM Coordinator, Columbia Cascades Cluster IPM Coordinator, and/or the County Extension Agent for the area.

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SAMPLE STINGING INSECT_ DATA MONITORING FORM

Date: Filed by.

1. Where in park did sting occur?

2. What was victim doing when stung (walking on trail, throwing trash away, sitting at table, other?)

3. How many times was victim stung?

4. Location of sting on victim's body?

5. What was the reaction to the sting? (pain and redness, swelling in area of sting, swelling of limbs, nausea, respiratory distress, other)

6. What was follow_up treatment? (application of gel, ice, referral to doctor)

7. Did victim receive printed materials on stings?

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SAMPLE STINGING INSECT MONITORING FORM

Date: Map Reference: Recorder:

EVENT:

1. Time, weather (overcast, bright, windy), and temperature when stinging incident occurred:

2. Specific park location where sting occurred (picnic area, path, recreation area, forested area, other):

3. Species causing the sting (yellowjacket, wasp European honey bee, Africanized honey bee, etc.; who/how identified?) and behavior:

4. Activity of victim when stung (walking on trail, throwing trash in can, sitting at table, other):

5. Number of times victim was stung:

6. Location of stings on victim's body:

7. Victim's physical reaction to stings? (pain and redness, excessive swelling in area of sting, swelling on limbs, difficulty swallowing, difficulty in breathing, nausea, disorientation, etc.):

8. Was the victim treated (application of ice, referral to doctor, self_treatment, etc.):

9. Had the victim received printed or posted information on the presence of, or precautions against, stinging insects in the park:

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OBSERVED FOOD AND WASTE MANAGEMENT PRACTICES

1. Are concessions providing food covers and/or lids/straws for beverage containers:

2. Are garbage containers tight against bees and wasps:

3. Are garbage cans overflowing because of infrequent pickup:

4. Are the insides (including bottom under the plastic liner) of the garbage cans clean:

5. Are there enough garbage cans:

6. Are external garbage spills cleaned up or hosed down:

MONITORING

1. Counts of yellowjackets/bees/wasps that visit garbage cans over 10 minutes (identify can on an attached map):

2. Presence of active stinging insect nests in the area (identify on a map):

EMPLOYEE COMMENTS AND RECOMMENDATIONS:

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THISTLES

Common Name

Five species of thistle are currently considered major pest weed species by the National Park Service and are under chemical, biological, or cultural control programs in North America. The species listed below were introduced from Europe and North Africa into North America and are found in the park.

Canada thistle (*Cirsium arvense*) is found throughout North America except in Alaska, and is most common in northern tier of states and southern Canada. Canada thistles are perennial thistles which flower in June-October.

Bull thistle (*Cirsium vulgare*) is found in southern Canada and throughout the United States. Bull thistles are biennial thistles which flower in July-September.

See Fernald (1950), pages 1538-1542, and Peterson and McKenny (1968), pages 302-306, for descriptive keys and illustrations of thistle species. See also Moore and Frankton (1974) for detailed keys to species.

Identification and Biology

Thistles are pioneer species and are most often found in sites where the ground cover has been disturbed by grazing, erosion, traffic, or other means. Thistles reduce the use of an area for grazing or recreational purposes because of the prominent spines on leaves, stalks, and blooms. Livestock do not eat thistles and will not graze between thistle plants on more desirable forage.

Each thistle produces many seeds, often in excess of 10,000 seeds per plant. The fine filaments or pappus (thistle down) of the seed coat permit windborne dispersal over long distances to suitable habitats. Reinfestation occurs from roadsides or other areas where control is not practiced or by long-lived seeds stored in the soil from previous years. Newly germinated thistle seeds require considerable light and usually become established on disturbed areas of pastures or croplands where competition is limited during the seedling stage. Foliar growth occurs during the spring, summer, and fall. The amount of growth and rate of new establishment varies from region to region according to the geographic, ecologic, and climatic characteristics of each region.

Losses in cultivated crops are as high as 60% at usual levels of infestation (25 shoots of Canada thistle per square yard). Losses in productivity of forage grasses from Canada thistle at a density of less than two shoots per square meter are as high as 15%.

The introduced thistles represent a range of life histories, and the life history of each species may vary depending on habitat conditions:

> Summer annuals grow each spring or summer from seed. They grow, mature, produce seeds, and die in one growing season. Seeds generally overwinter before germinating the following spring.
>
> Winter annuals germinate in late summer or fall from seed, then mature and produce seed the following spring or summer. Seeds are dormant during the spring.
>
> Biennials germinate any time during the growing season. They usually produce a rosette of leaves close to the soil during the first season, then flower (using energy and nutrients stored during the first season's growth), mature, and die during the next year.
>
> Perennials become established by seed or vegetative parts (e.g., roots, tubers, or rhizomes). Once established, they live for more than 2 years, and often for many years.

Occurrence in the Park

Thistles occur on all park sites, in varying degrees. Those areas where disturbance has occurred are subject to

greater infestations.

Potential Damage and Health Concerns

Thistles are important rangeland and pasture weeds in North America. They rapidly invade overgrazed rangeland and other disturbed sites. These invasive weeds do not present any human health concerns. Thistles can drastically alter the historic and cultural scene of areas.

Monitoring and Thresholds

Thistles are relatively conspicuous weeds and in most cases periodic visual inspections should be sufficient to monitor thistle populations. The permanent plot photograph technique is a good way to monitor thistle populations after they have become established and while they are being controlled. A representative section of the field is marked off. Take a series of photographs of the sample plot showing the density of thistles and condition. Include in the photo an object of known size (person or measuring stick) to indicate thistle size. Also include in the frame a sheet of paper with the date in bold letters. All photos should be taken from the same location with the camera pointed in the same direction and with lenses of equal coverage. This method is especially useful in monitoring the effects of control measures over the course of several seasons. Thistles in each photo can be counted and mapped and notes made on their condition (height, flowering, etc.). Monitor on a regular basis (monthly). Keep careful records, note when treatments take place, or when biological controls are introduced (naturally or artificially). Study of records, over time, will show population trends and indicate whether or not control strategies are successful.

Non-chemical Management

Although most species in the subfamily cyraneae are native and are beneficial for wildlife, a number of introduced species are well known as serious weeds of crops and rangelands. The pest status of introduced species results from the lack of population suppression exerted by natural enemies (e.g., insect herbivores and diseases). Thus, long-term goals in thistle management emphasize biological and cultural controls, although emergency intervention with chemical or mechanical controls may be necessary.

The primary control strategy for annuals and biennials is seed management while the control strategy for perennials must include depletion of plant reserves. Generally, no one technique will provide adequate control. Currently available biological controls using insects require several years for establishment of the insect, and even longer for control. Most successful programs combine biological control with cultural controls such as timely mowing or reseeding with competitive desirable plants. Suppression of thistles may require altering land use.

Pest species of thistles have been introduced into North America without their compliment of natural enemies. In Europe, *Carduus* thistles are attacked by approximately 340 species of insects and 7 fungal pathogens. Current research in biological control is an attempt to reunite natural enemy species with their hosts. Biological control agents seldom eliminate pest thistles from an area, but can reduce populations below set economic thresholds.

Imported thistles have been the subject of biological control programs for several years. For control of Canada thistle, *Altica carduorum*, a European weevil has been imported into North America. Adults feed throughout the summer on leaves, defoliating the plant and weakening it. Although Canada thistle is seldom killed outright by this weevil, the continued stress upon it reduces the number and vigor of vegetative shoots and reduces seed production. Although repeatedly released in North America, this species is not yet well established.

A second weevil, *Ceuthorhynchus litura*, that feeds on leaves and root crowns of Canada thistle is established and providing some control in Canada, Idaho, Montana, and California.

A tephritid fly, *Erophora cardui*, that feeds on Canada and bull thistles was released in 1973 and is established in British Columbia.

Cassida rubiginosa, a chrysomelid beetle that feeds on leaves of *Carduus* and *Cirsium* thistles, has been established in North America since 1927.

Several other species of insects, mostly seed-head weevils, are currently being studied for possible importation and release for biological control of thistles in the United States.

Two fungal pathogens that are spread by thistle feeding insects are also being considered for release in the United States. Rust fungi in the genus *Puccinia*, which attack the leaves of the basal rosette and underground basal parts, have been introduced into Canada. Further studies are required to determine their effectiveness.

Ustilago cardui, a smut fungus, has been observed attacking late maturing seed heads of *Carduus* thistles in Europe. Seed production is stopped in infected plants, giving full control. This fungus compliments control by *R. conicus*, which feeds on early flower heads.

Cutting or removing thistles (where feasible) can be effective in reducing thistle populations. Annual and biennial thistles, if mowed within two days of flowering of the terminal blooms, will not produce seed or regenerate significantly. Timing in mowing is important; if mowing occurs four days after terminal bloom anthesis (full flowering), significant amounts of seed are produced. Since thistle stands mature at different times, careful monitoring and proper timing are necessary for mowing to be a viable option in an Integrated Pest Management program. However, even if mowing is done late and seed is produced, mowing the stalks will reduce seed dispersal and seed production, keeping infestations from spreading widely.

Canada thistle, a perennial, is difficult to control by mechanical methods. Occasional cultivation may increase sprouting from broken roots due to its ability to propagate vegetatively. However, repeated cultivation can significantly reduce infestations if begun when plant reserves are at their lowest stage in early spring (early bud stage), before the shoot leaves can furnish energy to the roots in amounts greater than the roots require for production of new growth. Cultivation should start in early spring by plowing and disking. When new shoots appear, the area should be cultivated 3"to 4" inches deep every 20-21 days to destroy new shoots. Up to 90% or more of a Canada thistle infestation can be eliminated in a single season of cultivation when properly performed. Remaining plants can be eliminated by continuing cultivation in the following spring. One study reported excellent control of Canada Thistle in alfalfa fields mowed for hay twice a year.

Mechanical controls are compatible with biological controls if the mechanical controls are used early in the season to stress the plants, and natural enemies are allowed to enter the system to further weaken and eliminate thistles. Mechanical controls combined with chemicals may be successful in some cases. In most cases, however, combining a chemical and biological control is a more viable approach to thistle management.

Controlled burning may only damage the above ground portion of the thistle allowing rapid regrowth from the root section or from seed. Fire should be used only in combination with other control measures.

Chemical Control

Several herbicides are useful for thistle control. Spot treatments, rather than broadcast treatments, are preferred. Chemical control for annuals, biennials, and perennials must be initiated before the plants blossom and produce seeds. Young plants are most susceptible to control with chemicals. Best results are obtained when plants are in their initial and heaviest growth stage. Use of herbicides provides a quick and easy (albeit expensive under largescale operations) method of control, but without a long-term strategy herbicides often lead to greater problems because of their effect on other plant species, development of resistance, and lack of susceptibility of certain life stages of thistles.

Trials combining herbicides (usually 2,4-D), and biological control agents (*R. conicus* and *T. horridus*) have shown the two to be compatible if precautions are taken. Field and laboratory tests have shown that spring application of 2,4-D (when blooms are beginning) provides the most effective thistle control, and causes the fewest adverse effects on thistle weevils; *R. conicus* adults and *T. horridus* pupae, the only life stages likely to be exposed to such spraying, are relatively unaffected by the herbicides. Adults of both species will move to unsprayed plants, thus increasing

biological control in nearby areas where herbicide treatment is not feasible or economical. Success has also been obtained by the use of Picloram (Tordon) and Glyphosate (Roundup).

In summary, the following steps are recommended to manage thistles:

1. Monitor infestations over time with the use of maps, plots, or photographs.

2. The primary control strategy for annuals and biennials is seed management, while the strategy for perennials must include depletion of plant reserves.

3. Use biological controls if possible. Check with the CCSO Integrated Pest Management coordinator for details.

4. Use cultural controls to reestablish dense grass or ground cover in order to prevent or reduce thistle establishment.

5. Cut, mow, or otherwise remove thistles, if feasible. Thistles should be cut before the flowering of terminal blooms to prevent seed production.

6. Use appropriate herbicides on a spot treatment basis. Time applications to control thistles at prebloom stage and for compatibility with natural enemies.

Approved Chemical Alternatives at NEPE:

2,4-D;
Picloram;
Glyphosate.

Other chemical alternatives that must have prior approval include:

Clopyralid;
Dicamba;
Paraquat.
Resources

Materials Available

Materials available include hand tools (eg. shovels, rakes, pruners, etc.), gloves, and approved chemical treatments.

Technical Experts

NPS-WASO IPM Coordinator, Columbia Cascades Cluster IPM Coordinator, and/or the County Extension Agent for the area.

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TICKS

Common Names

Ticks are external parasites on mammals, birds, reptiles, and amphibians. Both males and females feed on blood. This module describes the biology and management of four species of ticks that may be found in park settings. These ticks are all species which vector a disease, are capable of transmitting a pathogen to humans, or may in some other way affect human health. They are the American dog tick (*Dermacentor variabilis*), Rocky Mountain wood tick (*Dermacentor andersoni*), deer tick (*Ixodes dammini*), and *Ornithodoros* spp. For each species of tick, the geographic distribution, habitat, hosts, life cycle, seasonal abundance, responses to environmental factors, and direct and indirect medical effects are described. Information concerning the removal of ticks, outbreaks of tick-borne diseases, and natural enemies are presented. Tick management approaches including methods of population monitoring, decision-making, and intervention are described. All of these tick species are attracted to carbon dioxide and generally prefer low light intensity, high relative humidity, and protection from constant breezes. Temperature and humidity are the two most important environmental factors affecting survival.

Identification and Biology

The identification of medically important species of ticks can be done by local diagnostic facilities at universities or state agencies or with the aid of publications such as Keirans and Litwak (1989), Sonenshine (1979), and the United States Department of Health, Education and Welfare (1967), which provide keys and descriptions. *Ixodes dammini* was first described in 1979 and will appear as *Ixodes scapularis* in works prior to this date. A concise review of tick biology, management, and medical importance was provided by Goddard (1989).

Ticks are considered harmful because they transmit diseases. Like many other organisms, however, their role in the food chain serves a positive ecological function. Ticks are an essential food source for many reptiles, birds, and amphibians.

<u>American Dog Tick</u>

The American dog tick is found throughout the United States except in parts of the Rocky Mountain region. It also occurs in parts of Canada and Mexico. Its habitat includes wooded areas, abandoned fields, medium height grasses and shrubs between wetlands and woods, and sunny or open areas around woods. Larvae and nymphs feed primarily on small mammals (especially rodents), while the adults feed mainly on dogs, but will readily bite humans.

The female lays 4,000-6,500 ellipsoidal eggs over a 14-32 day period and then dies. The eggs usually hatch in 36-57 days. Larvae usually engorge for 3-5 days, nymphs for 3-11 days, and adult females for 5-13 days. Unfed larvae can live up to 15 months, nymphs 20 months, and adults 30 months or longer. Mating takes place on the host. Adults are active from mid-April to early September. Nymphs are active from June to early September and larvae from late March through July. High light intensity and low relative humidity stimulate questing behavior.

This species is the primary vector of Rocky Mountain spotted fever in the eastern United States, and can also transmit Tularemia and cause tick paralysis.

Rocky Mountain Wood Tick

This tick is found from the western counties of Nebraska and the Black Hills of South Dakota to the Cascade and Sierra Nevada Mountains, and from northern Arizona and northern New Mexico in the United States to British Columbia, Alberta, and Saskatchewan in Canada. Their habitat is primarily fields and forested areas. This species is especially prevalent where there is brushy vegetation that encourages the small mammal hosts of immature ticks and sufficient forage to attract the large hosts of the adults. Immatures feed mainly on small mammals such as ground squirrels and chipmunks, and adults on cattle, sheep, deer, humans, and other large mammals.

Females lay about 4,000 eggs in plant debris on the soil or in crevices in construction materials, usually in masses of hundreds at a single location. Unfed larvae may live for 1-4 months, nymphs for 10 months, and adults for more than 12 months. Adults and nymphs can be found from March to mid- summer. Larvae are active throughout the summer and are associated with cool soil temperatures, shallow soil, abundant leaf litter, and high relative humidity.

This species is the primary vector of Rocky Mountain spotted fever in the Rocky Mountain states and is also known to transmit Colorado tick fever and Tularemia. It also carries tick paralysis in the United States and Canada.

Deer Tick

The deer tick is found in eastern North America including the New England, mid-Atlantic, and southeastern states, and the midwestern states of Minnesota and Wisconsin. It has also been observed in Michigan, Iowa, Illinois, and Indiana. Deer ticks prefer heavily-forested or dense brushy areas and edge vegetation, but not open areas. An exception to this occurs in upstate New York where the species is found on well-maintained lawns in residential areas. Larvae and nymphs feed primarily on small mammals (especially the white-footed mouse, other rodents, and insectivores), and also on birds, dogs, deer, and humans. Nymphs aggressively bite humans. Adults feed primarily on deer, but also attach to large mammals (foxes, raccoons, opossums, dogs) and humans.

Females lay up to 3000 eggs in soil and litter. Eggs take about 1 month to hatch. Larvae engorge for 2-3 days during the summer, detach, overwinter on the ground, and molt the following spring. Nymphs feed for 3-4 days, detach, and molt in early fall. Adult females engorge for 7-21 days, detach, oviposit the following spring, and die. The life cycle may range from 2-4 years and is regulated by host abundance and physiological mechanisms. Larvae are active from July through September, nymphs from May through August, and adults in the fall, winter, and early spring (October-May).

Distribution is associated with high humidity and mild mean winter temperatures. However, it is not restricted by winter temperatures as areas of tick activity occur in Minnesota and Wisconsin. The requirement for high humidity restricts this tick from spreading to arid areas and high mountains where desiccation is a limiting factor.

The deer tick is the major vector of Lyme disease in the northeastern and midwestern United States. It is incriminated as the vector of human babesiosis in the northeastern United States.

Ornithodorus spp.

These ticks are the vector of relapsing fever, which has created serious health problems at the Grand Canyon. The relapsing-fever tick, *Ornithodorus hermsi*, is sand-colored before feeding, but turns grayish-blue after it feeds. The adult female is about 1/4" long.

Occurrence in the Park

Ticks may be found in all areas of the park, but especially in areas where brush and tall grasses occur.

Potential Damage and Health Concerns

Ticks may cause paralysis in humans that is reversible when the ticks are removed. Symptoms include paralysis of the arms and legs, followed by a general paralysis which can be fatal if not reversed. The victim may recover completely within a few hours of the removal of the tick. The paralysis may be caused by a salivary toxin transmitted to humans when a tick feeds. Tick paralysis is frequently associated with the attachment of the tick at the base of the victim's skull; however, the illness occurs from attachment to other parts of the body as well. The highest incidence of tick paralysis in north America occurs near the border of British Columbia, Canada, and the northwestern United States.

The two most important tick-borne diseases in the United States are Lyme disease and Rocky Mountain spotted fever. The onset of Lyme disease is usually characterized by the development of a large, red rash which may develop a characteristic clear central area ("bulls eye"), one to two weeks after a tick bite, often in the area around the puncture. Other symptoms include joint pains, flu-like symptoms, and neurological or cardiac problems. The most characteristic symptom of Rocky Mountain spotted fever is a rash on the ankles, wrists, and forehead one to two weeks after the victim is bitten. The rash spreads to the trunk and is accompanied by fever, chills, and prostration. Both Lyme disease and Rocky Mountain spotted fever are transmitted after the tick feeds for several hours. Prompt removal of attached ticks greatly reduces the chances of infection. Both diseases are usually successfully treated with antibiotics in their initial stages. Therefore, early diagnosis is imperative. For this reason, it is recommended that the date of a tick bite be marked on a calendar. If unexplained disease symptoms occur within two to three weeks, a physician should be consulted.

The best means to prevent the transmission of tick-borne diseases and the development of tick paralysis is the prompt removal of ticks. This requires regular inspection of clothing and exposed skin for attached or unattached ticks. To remove a tick, grasp it crosswise with narrow tweezers (do not rupture the tick) as close to the point of attachment as possible. Retract or pull tick firmly in the direction of attachment; some back-and-forth wiggling may be necessary. Do not twist or rotate the tick. Do not handle ticks with bare hands because infectious agents may enter through mucous membranes or breaks in the skin. Removed ticks should be immersed in alcohol to kill them. Disinfect the bite site and wash hands thoroughly with soap and water.

The diseases listed above can be fatal. Any case of such a disease should be reported to medical authorities immediately. Frequent or multiple reports of tick-borne diseases should be reported to a National Park Service public health service representative. The representative can recommend actions to control disease outbreaks. Closing affected park areas may be advisable during such periods.

Another important tick-borne disease is endemic relapsing fever. This disease is limited to the western states and is caused by a spirochaete carried by certain ticks in the genus *Ornithodorus*. These ticks are found on tree squirrels (*Sciurus* spp.) and western chipmunks (*Eutamias* spp.). The disease can also be transmitted directly to the tick's offspring. These ticks usually live three to five years. Park personnel and visitors are at increased risk of contracting endemic relapsing fever when they sleep in dwellings that have become inhabited with infected squirrels or chipmunks. As with sylvatic plague, the rodents vacate the building or are killed by the humans who use the buildings. The ticks which remain behind feed on the people using the buildings. Implementation of exclusion efforts will reduce the incidence of ticks.

Monitoring and Thresholds

Periodic surveys of potential or known tick habitats can reveal the presence of low-level tick infestations. This permits the application of management procedures to prevent or retard further population increase. Monitoring techniques that have proven effective are as follows.

Examination of personnel for attached ticks. A volunteer wearing protective clothing walks through each sample site and is then inspected. Ticks attached to or walking on the collector's clothing and skin are collected in 70% ethanol for later identification and counting. Careful inspection is necessary to prevent the attachment of unnoticed ticks and possible disease transmission to the collector. Collections can be standardized in relation to time, distance, or area units covered during sampling.

Dragging/flagging. Done by dragging a white cloth over relatively open ground or "flagging" low-level vegetation (i.e., moving the cloth in a waving motion over and through vegetation) in densely brushy ground. Ticks that are questing for passing hosts cling to the cloth and can be removed for identification and counting. The "drag" consists of a 1 yd piece of white crib bedding or corduroy material hemmed on all edges, weighted at one end, and attached to a wooden pole at the opposite end. A rope attached to the two ends of the pole allows the device to be dragged along the ground. Alternatively, the pole can be gripped at one end so that the cloth hangs vertically downwards, and the device used to flag vegetation. Dragging or flagging success depends upon the degree of contact between the cloth and ground or vegetation surface. Useful drag techniques are described by Gladney (1978). The selection of sampling sites may have significant effects on the success of the sampling effort. Sampling sites should reflect favored tick habitats for best success. Sampling should be done under conditions that favor tick presence and activity (e.g., when vegetation is not wet and when ambient temperature is above 50^{o}F).

Dry-ice traps. This has been proven to be the most efficient method of tick collection. It is non-destructive to host animals, does not require a human as an "attractant", and gives more reproducible results than dragging. However, the traps need to be kept in the field for several hours (preferably overnight) for best results. Dry ice is available at ice cream and beverage stores. The basic principle is to use carbon dioxide vaporizing from the dry ice to attract ticks onto a white cloth panel on which they are easily visible and can be removed periodically (if the traps are set out for a limited time under periodic monitoring), or onto a platform lined with double- sided sticky tape on which they get trapped (if the traps are set out overnight). Information on trap designs can be obtained from Garcia (1965), Gladney (1978), and Mount and Dunn (1983).

Trapping small animal hosts. Small mammals such as rodents and insectivores can be live-trapped at selected sampling sites, with traps set out in grids or line transects. Trapped animals are anesthetized and searched thoroughly for attached ticks, which are removed using fine forceps. Removed ticks can be stored in 70% ethanol pending identification and counting. The animal host is released at the site of capture after recovery from anesthesia. Gloves should be worn throughout all animal and tick handling operations. A veterinarian or qualified technician should be consulted on the proper usage of anesthetics administered to trapped animals.

Sampling sites for monitoring ticks should be selected in areas favoring ticks or are likely to receive heavy human visitation. A conscientious monitoring program is the basis of effective integrated pest management. Regular surveys should be done at all sites where ticks have been reported by park staff or visitors and at other locations that appear to be favorable tick habitats. Complete and accurate records of sampling sites and methods must be kept, so that the progress of tick populations and the effect of control measures can be gauged. After collecting the ticks, store them in rubbing alcohol or freeze in a plastic container to preserve them.

Mount (1981) proposed an arbitrary tolerance threshold of one tick/dry-ice sample, based on several years of study in recreational areas in Oklahoma. Mount and Dunn (1983) recommended that a count of 0.65 ticks per one hour of CO 2 exposure (dry-ice traps) be considered the economic threshold in lone star tick management (equivalent to one tick per visitor per day, based on the assumption that most human visitors to recreational areas will not spend more than one hour per day in tick habitats). This value may not be applicable to your particular situation and a suitable threshold level can be established by conducting regular CO_2 surveys and plotting tick counts against the numbers of tick bite complaints received. This will permit the selection of a complaint threshold level for each site surveyed. Treatment should be conducted to keep tick populations below the selected threshold; a lower "action" level should be selected to trigger treatment programs. The same technique is applicable to other species of ticks as well.

Non-chemical Control

Ticks are important disease vectors in many regions of the country. Park visitors and employees need to be aware of tick species and diseases present in their area, as well as personal protection measures that should be taken by

anyone who will be in tick-infested areas. Parks should use interpretive displays to inform their visitors about ways to avoid contacts with ticks.

Several species of ants are known to feed on ticks. Recently, releases of the parasitic wasp *Hunterellus hookeri* have been made on several small islands on the New England coast. This wasp attacks *Ixodes dammini* and has been recovered from some of the release sites (Van Driesche, personal communication).

Wherever possible, visitor activities should be directed towards areas that provide unfavorable habitat for ticks. Regular inspection of the park should be performed to determine when tick management needs to be initiated. The basic principles of management include isolation of susceptible domestic animals from known tick populations and rotation of pasture or run areas to reduce tick populations.

Removal of shrubs, trees, or tall grass can be useful in situations where it is consistent with National Park Service policy regarding use of the area. Dense shrub and tree cover and tall grass provide harborage for both ticks and their animal hosts. Removal of excess brush and shrubbery and clearing the canopy trees so that 50% to 80% of a management area is exposed to direct sunlight at any time are recommended control practices for walkways, parks, and landscaped grounds. Grass should be kept below 6" in height to allow the penetration of sunlight and soil ventilation. Such techniques result in higher soil temperatures, lower humidities, and lower soil moisture, all of which lead to higher tick mortality. In one study, such techniques resulted in 75% to 90% control of different tick life stages of the Lone Star tick. Mowing vegetation with a bush-hog rotary mower reduced adult deer tick populations by 70% in another study. Within areas designated as a cultural landscape, consultation with an historic landscape architect may be necessary to perserve an historic setting.

Controlled burning of habitat may reduce tick numbers and may be feasible in a park if it is consistent with a fire management plan. For example, burning tick- infested areas on Great Island, Massachusetts, reduced deer tick populations by 38% six months after the burn. However, the long-term implications of burning are unclear. Burning typically improves deer browse in the area; thus increased deer abundance may result in the movement of ticks back into the area.

Research has shown that high deer populations can lead to increased Lone Star and deer tick populations since there will be more hosts from which a blood meal can be obtained. Reducing the deer population may be a feasible tick management strategy in locations where it is compatible with National Park Service policy. This reduction has been experimentally demonstrated in Massachusetts, although the decline in tick numbers may not correspond directly to the reduction in deer population. Managing deer populations by hunting, fencing, or environmental modification should be considered seriously before tick infestations become severe and should be done within state and local guidelines. Efforts at deer management should be done in coordination with state natural resources and wildlife department personnel.

Under unusually high tick population pressure it may be necessary to treat indoor areas. The major methods of nonchemical indoor tick management include regular inspection, elimination of animal (especially rodent) harborage areas, use of food and waste-handling procedures that minimize animal entry and harborage, and animal-proofing buildings. This includes sealing all holes in foundations and walls, and screening (with heavy gauge metal screen) aboveground windows, vents, and other openings through which animals may enter. A 18" perimeter border of gravel may prevent movement of ticks from grass areas into buildings. Cracks and crevices around the base of buildings should be sealed with caulk.

Recommended practices include frequent examination of clothing (preferably by another individual) and the body (after showering), destruction of collected ticks, and wearing protective clothing (e.g. coveralls with trouser cuffs taped to shoes, high- top shoes, socks pulled over trouser cuffs, long-sleeved shirts or jackets, or mesh jackets). Clothing should be light-colored so ticks may be easily seen.

Periodic surveys of potential or known habitats can reveal the presence of low- level tick infestations, thus indicating the need for application of management practices to prevent or retard further population increase.

Chemical Control

Insecticides or acaricides. Several insecticides and acaricides that provide effective control of tick populations in small infested areas. At least two treatments are required for control; one in the spring for adult and nymphal stages and the other in late summer for larval stages. Surveillance is necessary to determine times of application (see Monitoring section for techniques). Low to moderate infestations can usually be controlled by one spring and one late summer treatment; heavy infestations may need two or more treatments in the spring and again in late summer and early fall. Consult your regional Integrated Pest Management coordinator to determine pesticide choice and application rates.

Aerial dispersal of acaricides requires coordination with local, state, and sometimes federal officials. Chrlorpyrifos in a 14% granular formulation applied at 7 lb/acre has been used successfully in tick control by this method. The National Park Service, however, does not currently use this method due to extensive bird kills associated with chlorpyrifos.

Vegetation management by herbicides is another tick control option. It produces the same benefits as mechanical management of vegetation; i.e., reduced harborages for animal hosts of ticks, reduced soil humidity, and increased soil temperature, all of which are detrimental to tick survival. Management of vegetation by herbicidal and mechanical methods may not always produce comparable results; Hoch et al. (1971) found that herbicidal treatment of woodlots was not as effective as mechanical vegetation clearing in reducing the population of Lone Star ticks.

Personal protection. Ticks may be prevented from attaching to the skin or clothing by the use of repellents. Schreck et al. (1980), reported that DEET, M-1960, and permethrin provided 81%, 95%, and 89% protection, respectively, against the Lone Star tick. Mount and Snoddy (1983) showed that the application of pressurized sprays of 20% DEET to the exterior of surfaces of clothing provided 85% protection against nymphal and adult Lone Star ticks and 94% protection against adult American dog ticks. Permethrin (0.5%) gave 100% protection against both species.

However, DEET and M-1960 have a disagreeable odor and can cause skin irritations. The most effective repellent/toxicant against all tick species available at present is Permanone (0.5% permethrin), which must be used as a clothing treatment; Permanone is not intended to be sprayed directly onto the skin (Goddard 1989). Permanone remains effective for at least 1 month on unwashed clothing. All pesticide-treated clothing must be washed separately.

Sites such as crevices, baseboards, trimming, furniture, ceilings, floors/carpets, walls behind pictures, bookshelves, and drapes should be spot-treated as needed. Crack and crevice treatments should be done with residual dusts or silica gel. This is the most effective way to use pesticides in a building. Fumigation does not work well in buildings because ticks can readily re-enter through doorways or windows.

For outdoor areas, habitat reduction by mechanical removal of excess brush and overstory and regular mowing of grass 6" or less in height is recommended. Regular CO2 or drag surveys of likely tick habitats will indicate locations where treatment is required. If nonchemical measures prove ineffective, registered herbicides (for vegetation management) or acaricides (for direct kill) may be needed.

Animal-proofing park buildings through the use of exclusion techniques should eliminate indoor tick habitats and reduce the chance of future infestations.

Recommended procedures for protection of park personnel and visitors include frequent examination of the clothing and body of any person travelling through tick habitats, wearing protective clothing, and the use of clothing and/or skin-applied tick repellents.

Information should be made available to park visitors concerning known tick habitats within the park, personal protection techniques, and tick removal techniques.

Approved Chemical Alternatives at NEPE:

Hypochlorite (household bleach) sanitizer;
Personal insect repellents containing DEET and/or permethrin.
Pyrethrum contact sprays;
Silica aerogel and sillca gel.

Other chemical alternatives that must have prior approval include:
Fenoxycarb (IGR);
Methoprene (IGR).

Resources

Materials Available

No materials available.

Technical Experts

NPS-WASO IPM Coordinator, Columbia Cascades Cluster IPM Coordinator, and/or the County Extension Agent for the area.

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TURFGRASS WEEDS

Identification and Biology

Weeds are usually described as any plants growing where they are not wanted. Any undesirable grass or broad-leafed plant species, from a small herbaceous plant to a woody shrub, vine, or tree, may be considered a weed if it is growing in a turf planting.

Dicotyledonous (broad-leafed) plants are those that have two cotyledons in each seed. They are characterized by broad leaves and often have woody stems. Some species (e.g., sunflower) only become woody in old parts of stems and roots; these are referred to as semi-herbaceous dicots. Most weeds in turf have little or no woody tissue and are herbaceous (e.g., plantains, dandelion).

Grasses are members of the plant family Gramineae. All grasses are monocotyledonous, have long, narrow leaves with parallel veins, and fibrous root systems. Some grasses produce underground stems called rhizomes (e.g., Kentucky bluegrass, quackgrass) or above-ground runners called stolons (e.g., creeping bentgrass), while others (e.g., bermudagrass) produce both.

It is important to understand the distinction between monocots and dicots since turfgrass herbicides kill only dicots. (Desirable turf species are monocots.)

Undesirable ("weed") plants will invade man-made environments such as turfgrass plantings wherever they are established. Weeds growing in turf are found where soil has been exposed or disturbed by compaction, planting activities, or maintenance activities such as sidewalk edging. For example, goosegrass and knotweed readily colonize heat-stressed and compacted soil sites along sidewalks or on athletic fields. They also occur where the turf is weakened by adverse environmental conditions (such as drought), thatch accumulation, diseases, or pests to the extent that the turf cannot compete for nutrients, water, or light with weed species. Exposure to de-icing salts, fertilizer or other chemical spills, and dog urine can also leave bare spots in which weeds will grow. Weeds are very common where the grass species being grown is not well-adapted to its environment. Many weed species possess efficient methods of seed dispersal such as wind dissemination of winged or hairy seeds or the ability to spread rapidly by rhizomes, runners, or tubers.

The description of each potential weed species is beyond the scope of this plan. The Cooperative Extension Service of the University of Idaho can provide specific information on weeds for the NEPE and BIHO area.

Life Cycles

The life cycles of turf weeds can be grouped into the following major types.

Summer annual weeds. These are weeds that grow each spring or summer from seed. Examples include prostrate spurge, ragweed, large crabgrass, and goosegrass. They mature, produce seeds, and die in one growing season. Seeds generally overwinter before germinating the following spring. The majority of annual weeds are of this type. Some annuals, such as crabgrass, can root from leaf-stem junctions, forming dense colonies.

Winter annual weeds. These are weeds that germinate in the fall or late winter from seed, mature and produce seed during the following spring, and die in early summer (e.g., henbit, shepherdspurse, annual bluegrass). Seeds of most of these species are dormant during the spring.

Indeterminate annual weeds. These are weeds such as chickweed and annual bluegrass, that germinate and grow during most seasons in certain regions.

Biennial weeds. These weeds may germinate at any time during the growing season. Examples include wild carrot, bull thistle, and mullein. They usually produce a radial cluster (rosette) of leaves lying close to the soil during the first season. In the second year they produce flower stalks (using food stored from the first season's growth), produce seeds, and die.

Perennial weeds. These plants live for three or more years. Some species may not flower the first year, while others may produce mostly nonviable seeds. Many perennials (e.g., curly dock, dandelion, and common milkweed) spread primarily by producing seeds, while others (e.g., field bindweed, white clover, silverleaf nightshade, bentgrass, and quackgrass) spread both by seed and vegetatively. Vegetative spread can occur by rhizomes, stolons, tubers, or rooting of stem nodes that touch the soil.

The seasonal abundance of weeds is related to their specific life cycles. Summer annuals grow from spring until fall and are killed by cold fall or winter temperatures. Winter annuals are present from fall to late spring, so they are usually not found during the summer. Biennials grow during the spring, summer, and fall of their first year, survive over the following winter, and flower during the next growing season. Therefore, some biennial stages are likely to be present at any time of the year. Perennials grow during each growing season. Their aboveground structures may die over the winter or may remain viable but dormant.

Knowledge of the life cycle of a particular weed species is an important part of its management. For example, mowing a patch of annual weeds to remove the flowers can prevent seed set, or avoiding cultivation in areas where there are weeds which reproduce by rhizomes will minimize new plants.

Impact of Weeds

The most obvious impact of weeds on turf areas is the competition with and replacement of turf by weed species. In the case of weeds that over grow an area and then die, such as crabgrass and knotweed, unsightly dead areas can be created. This often leads to the necessity for increased expenditures for turf renovation.

Toxicity to humans and animals is also a consideration. Some common weeds are poisonous if consumed (e.g., black nightshade, pokeweed, poison hemlock, and Johnsongrass); cause inflammation when touched (e.g., stinging nettle, and poison ivy, oak, and sumac); or cause allergic reactions (e.g., common ragweed and goldenrod). Visitor injury or annoyance can result from bees or wasps seeking nectar from some weeds. Furthermore, many weed plants or their seeds have spines, thorns, or burs which can create similar allergic effects.

Weedy areas provide habitat for desirable wildlife and beneficial insects but can also harbor rodents and arthropods such as ticks, mites, and fleas that might attack humans and domestic animals, or carry diseases that may infect humans and domestic animals. Weeds can also serve as secondary hosts for some fungal pathogens and insects that might attack desirable turfgrasses.

Occurrence in the Park

Turfgrass weeds may be found in all park areas which have either recreational or greenspace turf.

Potential Damage and Health Concerns

Turfgrass weeds can damage walk and roadways, limit recreational use, and present unkempt appearances. Some weed cause human allergenic reactions, and may even harbor rodent or pest populations which may support or cause other problems.

Monitoring and Thresholds

Monitoring for actively growing weeds should be done periodically throughout the growing season. Less frequent inspections should be made during winter and early spring to identify sites of soil disturbance or other adverse effects, which may give rise to future weed problems.

It is essential that all monitoring results be reported completely and accurately by site and date so that future surveys will cover the same areas. Recorded weed information allows the site manager to develop a weed history of an area. This will result in a more accurate prediction of future weed management needs.

Regular visual inspections of turfgrass areas should be conducted to look for actively growing weeds as well as newly germinated weed seedlings. Weeds are most likely to be found in areas where some type of disturbance has taken place, such as areas of soil compaction, areas of open soil, or areas of soil moisture extremes. Weeds also are likely to grow in turf that has been stressed. This could be the result of being mowed too short, heavy thatch accumulation, competition from trees, or insect or disease attack. Turf can be stressed from extremes in soil pH or the accumulation of road salts along roadways as well. "Dog blight" from animal urine, fertilizer or pesticide spills or misuse, localized wet or dry spots, or accumulations of debris can create open areas where weed infestations begin. Edging along walkways may also open up areas of bare soil where weed seeds can germinate.

Certain weed species tend to be found in certain habitats, so monitoring for a particular weed should be based on a knowledge of its biology. For example, crabgrass is a spring annual that needs light to germinate. Therefore, crabgrass seedlings are most likely to be found in bare or thinning areas in the spring. If they are not found in areas such as this, it is unlikely that they will be found in a shaded area of denser turf. Also, since crabgrass is a spring annual, it may be a waste of time to look for seedlings in mid-summer. This would be an excellent time to look for mature plants, however, to identify seed sources for the following year. Late fall would be the best time to look for seedlings of winter annuals such as henbit or annual bluegrass.

Monitoring protocols and Action Thresholds are listed under the section **"**Turfgrass Weed Management at Nez Perce National Historical Park".

Non-chemical Management

Established Plantings

Employ sound cultural practices including regular soil testing, proper fertilization at the correct time, mowing at the correct height and frequency, and deep irrigation when needed. Frequent shallow watering discourages root growth and can encourage weed seed germination and some turfgrass diseases. Mow no shorter than 2.5" for cool-season grasses such as Kentucky bluegrass, tall fescue, fine-leaf fescues, and perennial ryegrass to prevent weakening of grass and encouragement of weed seed germination. Always remove debris and heavy thatch from turf and alleviate soil compaction through core aeration.

It is recommended that through a park Vegetation Management Plan, all turfgrass areas within the park be renovated to regionally adapted species that are drought resistant. It is also recommended that watering schedules be established that will promote root growth in both turfgrass and tree species.

Finally, develop a regular monitoring program for weeds and disturbed areas. Set a tolerance level for weeds and remove them mechanically or with proper application of a registered herbicide when that level is exceeded.

New Plantings

Plant turfgrass species and cultivars that are adapted to the growing area and, if possible, resistant to diseases and insects. Even though it is more expensive, use certified seed which is free of noxious weed seeds. Renovation and new plantings should always be done at the times of year that are most appropriate for the particular species; i.e., fall for cool-season grasses and late spring for warm-season grasses. When preparing the area for planting, allow weed seeds to germinate and then cultivate or apply a non-selective herbicide to kill young plants. Cultivation without use of a non-selective herbicide is generally not recommended for weeds that produce rhizomes, stolons, or bulblets because it breaks these structures into smaller pieces and may therefore result in dispersal rather than control of the weed.

During establishment of turf, inspect regularly for weeds. Mechanically remove weeds found in small populations or spot treat areas with a concentrated weed population with a registered herbicides. Always check the herbicide label for information on seedling tolerance.

Cultural Methods of Turf Weed Management

Turf management practices that increase the health, density, and general vigor of grass will discourage weeds through competition. It is essential to use turfgrasses that are adapted for the specific planting area (i.e., region, climate, light intensity) and type of use (e.g., heavy traffic). This will promote the best possible sod development. When turf is established or renovated, grass seed, sod, topsoil, and mulches that are free of weed seeds should be used.

Turf maintenance practices should stress proper fertilization and liming based on the results of soil tests. The amount of nitrogen and timing of its application are extremely important factors for maintaining turf density and discouraging weed encroachment. Deep watering (to wet soil to a depth of 5"-8") when grass begins to show signs of wilting will prevent the development of shallow root systems and weak turf, and will help to reduce weed, disease, and insect problems. Frequent, shallow watering encourages the germination of some weed seeds and should be avoided.

It is also important to remove leaves or other accumulated debris from turf, since this can smother or shade the grass, allowing weeds to grow in its place. Heavy thatch is reduced by a combination of core aerification, maintenance of soil ph between 6.0 and 7.0, and use of balanced fertilizers with slow-release nitrogen. Thatch also can be avoided through the use of tall fescue or other bunch-type grasses (where adapted) and by avoiding excessive nitrogen fertilization.

Mechanical Methods of Turf Weed Management

For limited invasions, hand removal provides effective control of some weeds, especially on initial invasion. However, some weeds have lengthy taproots and if not removed will simply resprout. An understanding of the individual weed and biology is beneficial to weed control.

Frequent mowing will prevent or reduce seed production in some weed species. A few weed species such as Johnsongrass or poison ivy can generally be removed from turf by scheduled mowing. Cool-season grasses should be cut no shorter than 2.5" in height to prevent weakening of the grass plant, and high mowing will promote a dense turf that can more effectively compete with weeds. Despite proper mowing, weeds may still become a problem in turfgrasses. Lower mowing is desirable for some grasses such as bermudagrass and zoysiagrass.

Biological Control of Turf Weeds

No biological control agents for weed control are approved by APHIS for use in turf plantings.

Chemical Control

When chemical weed management is necessary, apply broadleaf herbicides primarily during fall or spring to mature turfgrass stands. Annual grass weeds are best controlled with preemergence herbicides applied in early spring, prior to weed seed germination.

In sites where extremely persistent, perennial weeds exist (e.g., quackgrass, bermudagrass, and red sorrel), a non-selective herbicide such as glyphosate should be applied twice on a 30-day interval. This is ideally done prior to tilling and a few weeks after tilling. The first application will kill existing weeds, while the second will kill weed seedlings which have germinated from seeds that were dormant in the soil. Being non-selective, glyphosate also will injure or kill desirable turfgrasses, flowers, and other herbaceous plants. Glyphosate, however, has no soil residual and treated areas can be reseeded within 24 hours of use.

When new areas of turf are being established, shallow cultivation will bring many buried weed seeds to the surface and allow them to germinate. This should be followed by an application of a non-selective herbicide such as glyphosate to control these weeds.

Broad leafed weeds are generally controlled or reduced to below threshold levels with a single fall or spring

application of a selective herbicide. Do not use these herbicides unless there is sufficient soil moisture to support active growth of weeds. Air temperatures should range from 65 to 85°F, and there should be no wind when these herbicides are applied. Liquid or sprayable herbicide formulations provide superior control than granular formulations. Carefully read and adhere to all information and directions outlined on the label.

Annual grass weeds include species such as crabgrass, goosegrass, foxtails, sandburs, etc. These weeds are considered major weeds because they can effectively compete with grasses and can significantly reduce turf stand density in a single season. High mowing greatly retards annual grass weed populations, but when monitoring indicates increasing populations of annual grasses, an application of pre-emergent herbicide should be planned for the next spring. To be effective, these herbicides must be applied in early spring prior to weed seed germination and they must be watered-in by rain or irrigation within three to five days of application. Watering-in is critical and in the absence of irrigation these herbicides are best applied on a rainy day. Consult a turfgrass specialist or your county cooperative extension service for information about appropriate application times and herbicide selection in your area.

The postemergence approach to annual grass weed control requires more knowledge and professional skill to be effective. Consult an extension turfgrass specialist in your region for more detailed information on herbicide selection and use.

Approved Chemical Alternatives at NEPE:

2,4-D.

Other chemical alternatives that must have prior approval include:

Triclopyr

Resources

Materials Available

Materials available include hand tools (eg. shovels, rakes, pruners, etc.), gloves, and approved chemical treatments.

Technical Experts

NPS-WASO IPM Coordinator, Columbia Cascades Cluster IPM Coordinator, and/or the County Extension Agent for the area.

Turfgrass Weed Management at Nez Perce National Historical Park

The National Park Service manages turfgrass in three management zones: developed, special use, and historic. In each management zone the visual objective for turfgrass quality depends on the management objectives established for the park and management resources available.

Generally, turfgrass can be classified into three classes: ornamental turfgrass, recreational turfgrass, and greenspace turfgrass. These classes will determine the type and level of maintenance each should receive. These classes will also be used in integrated pest management to determine thresholds and management strategies for specific pests. The following guidelines have been developed specifically for weed management in turfgrass to assist in determining where and when the use of herbicides would be appropriate.

The intent of these guidelines is to sustain the quality of turfgrass appropriate for specific sites, while minimizing dependency upon herbicides to achieve this quality. This can best be done by using a fully integrated turf management program which defines the site objectives, assures objective monitoring, and encourages cultural management practices.

Turfgrass Classification

Class A. Ornamental turfgrass

Lawns classified as ornamental have the highest visual quality objective. Turfgrass must appear uniform in color and texture with weeds and bare spots unnoticeable to the general public. Ornamental lawns are exposed to minor foot traffic and receive the highest level of maintenance. Ornamental lawns provide the setting for memorials and other significant sites and features. Considering the intensive maintenance these areas require and that visual quality necessitates limited visitor use, managers should restrict the Class A designation to the minimum area necessary to achieve the visual management objective.

Class B. Recreational turfgrass

Turfgrass which provides the setting for certain passive recreational and athletic activities can be classified as recreational turfgrass. Class B areas would include small urban parks and some playing fields for organized sports, as well as turfgrass surrounding offices, parking lots, and other support facilities. Although such areas may have ornamental significance, the visual quality and level of maintenance is less demanding than ornamental turfgrass. Visitor use is common and some weed infestation is tolerable. The uniformity in color and texture is not as critical as in ornamental areas.

Class C. Greenspace turfgrass

Greenspace turfgrass encompasses large areas that receive minimal maintenance other than mowing. The aesthetic objective for the site is achieved simply by the presence of turf and not by its quality. Greenspaces would include large picnic and informal recreation areas, parkway medians, and roadsides.

Table 1. Turfgrass designations at NEPE and BIHO.

Table 1. TURFGRASS DESIGNATIONS AT NEPE AND BIHO	
Designation	Park Areas
Class A. Ornamental Turfgrass	None
Class B. Recreational Turfgrass	Spalding: Spalding: Visitor Center lawns Big Hole: Visitor Center grounds; residential turf
Class C. Greenspace Turfgrass	Spalding: picnic area and Agent's area; mowed trails; "ball field"; "Green house" lawn; roadway and parking lot buffers; maintenance area. East Kamiah: entrance area; trails. Canoe Camp: all grounds. White Bird: interpretive trail. Big Hole: siege area and village trails. Bear Paw: picnic area; interpretive trails.

Table 2 lists the permitted treatments by turfgrass classifications.

Table 2. Permitted Treatments by Turfgrass Classification.	
Turfgrass Designation	Permitted Treatment Actions
Class A. Ornamental Turfgrass	**Spot treatment.** Spot treatment may be considered when an action threshold of 15%- 29% weed cover is reached. Treatment must be limited to those areas that have reached the action threshold and can be sprayed with a backpack or other similar single nozzle, small capacity sprayer. **Recovery treatment**. An action threshold of 30%-49% weed cover indicates a possible need for broadcast application of herbicides by backpack or tractor-mounted, multi-nozzle boom sprayer. Treatment must be preceded by a complete review of the turf management program to determine why the weed level reached the Recovery action threshold. The review will examine the level of use, compaction, turf variety, mowing height, moisture management, fertility, ph.., and other factors considered pertinent to maintain Class A turf. Herbicide applications must be used in conjunction with other tactics to remedy the management deficiencies or site factors responsible for weed infestation. Recovery treatments will not generally be approved for consecutive years. **Renovation**. When the action threshold reaches 50% or greater weed cover, complete renovation is warranted. Renovation will be preceded by broadcast application of glyphosate or other similar broad-spectrum, post-emergent, short-residual herbicide that kills all vegetation. The treatment must be preceded by review of the overall turf management program as described for recovery treatments. The site will be seeded or sodded as appropriate. All other management or site deficiencies determined in the review must be corrected.
Class B. Recreational Turfgrass	**Spot treatment.** Not permitted in recreational turfgrass. **Recovery and renovation**. As described for Class A turfgrass.
Class C. Greenspace Turfgrass	Herbicide applications are not permitted on Class C turfgrass.

Monitoring and Thresholds

Routine monitoring by the park IPM Coordinator and maintenance staff will keep managers aware of changes in turf status. Herbicide application must be supported by monitoring data that demonstrates that action thresholds have been reached. Visual estimates are often inaccurate and are unacceptable as justification for herbicide application. Monitoring facilitates the identification of the weed species present. Species identification is critical in developing the appropriate management strategy. Post-treatment monitoring provides a measure of the efficacy of the overall management program. Proper monitoring will also determine the percent bare ground that is susceptible to weed invasion.

Monitoring will be performed by randomly selecting monitoring points by the toss of a marker (rock, ball, etc.). The marker can be thrown at five random points in an "M" pattern spread over the expanse of the area to be examined. Measurements at the monitoring points will be made by placing a 1 meter grid, over the marker at the center. Each square of the grid will be categorized as to what dominates the majority of the square (turf, weed, or bare ground). For example, 54 squares of turf would equal 54% turf, 33 squares of weed equals 33% weed, and 13 squares of bare area are 13% bare. If possible, determine what weed species are present. This is important because the life cycle of a weed is a consideration in determining how to manage it. For example, it is not a good idea to cultivate an area with perennial weeds which produce rhizomes, since this will cause more plants to be produced. Winter annuals will set seed in early spring and could be mowed before this to prevent seed formation.

Table 3 summarizes the herbicide treatment options based in turfgrass class and percent of weed cover. If herbicides are going to be part of turf weed management strategy at a particular site, this will aid in deciding the most appropriate way in which to use them.

Table 3. Herbicide Treatments by % Weed Cover

% Weed Cover	**CLASS B**	**C LASS C**
0% TO 14%	CULTURAL	CULTURAL
15% TO 29%	CULTURAL	CULTURAL
30% TO 49%	RECOVERY	RECOVERY
> 50%	RENOVATION	CULTURAL

Safety

All herbicide applications must be made in the early morning or evening before or after visitors are present. Treatments must be made in a safe and responsible manner either by a licensed applicator or individual working under the "line of sight supervisor" of a licensed applicator. Treated areas must be posted.

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YELLOW STARTHISTLE

Common Name

Yellow starthistle (*Centaurea solstitialis*), is native to southern Europe, and was introduced into western North America in the mid_1800's. Yellow starthistle is naturalized across southern Canada and most of the United States with the possible exception of the southeastern states. High densities are concentrated in California, Oregon, Washington, and Idaho.

Identification and Biology

Yellow starthistle occurs in grasslands, pastures, disturbed sites, and open woodlands. It commonly occurs with other exotic annuals. Yellow starthistle is present in the California annual grasslands which are dominated by nonnative grasses in the genera of oat (*Avena spp*.), brome (*Bromus spp*.), and barley (*Hordeum*). Yellow starthistle is codominant with cheatgrass (*Bromus tectorum*) on rangeland in southeastern Washington, northeast Oregon, and north-central Idaho.

Yellow starthistle is an introduced winter annual with a deep taproot. The stems, which grow 0.7 to 2.6 feet (0.2_0.8 m) tall, are rigid and branch from the base. Flowerhead bracts have 0.2_ to 1_inch (0.6_2.5 cm) long, sharp, rigid spines. Yellow starthistle has two types of seeds, plumed and plumeless. A fine, white pappus (plume) is 0.12_ to 0.16_inch (3_4 mm) long on seeds in the flowerhead center but is lacking from those at the margin of the flowerhead.

Yellow starthistle reproduces exclusively by seed. Vigorous plants may produce 170,000 seeds per plant, but seed production is generally much lower when plant densities are high. A site in southeastern Washington with an average of 16 mature yellow starthistle plants per square foot (180/sq m) produced an average of 1,890 seeds per square foot (21,000/sq m). Individual plants averaged 2 seedheads and 120 seeds per plant.

Plumed and plumeless seeds are dispersed at different times, which may maximize seed survival. Plumed seeds are dispersed shortly after maturity. Plumeless seeds remain in the seedhead until repeated drying and wetting cause the seedhead to fall apart in the fall or winter. Plumed seeds are dispersed by wind, but yellow starthistle has a small plume relative to seed size.

Yellow starthistle requires light on the soil surface for winter rosette and taproot development, and it requires ample soil moisture in early to mid_summer. The current northern limit of yellow starthistle is 49 degrees north latitude. In northern Washington, yellow starthistle is restricted to warm microclimates such as steep, south_facing slopes. In south_central Washington, which is dry and hot, yellow starthistle is restricted to deep soils that receive or store adequate water. Optimal growing conditions in southeastern Washington include deep silt loam soils, south_facing slopes, and adequate moisture. In California, yellow starthistle occurs below 4,260 feet. In Utah, it occurs from 3,000 to 6,200 feet (915_1,900 m) elevation.

Yellow starthistle is intolerant of shade. Rosettes are susceptible to shading from overtopping vegetation in the fall and spring. Yellow starthistle successfully invaded established perennial grass stands that were clipped, but did not invade unclipped areas. Root growth during the winter enables yellow starthistle to outcompete other species for moisture during spring and summer. Yellow starthistle utilizes moisture below the reach of most competing vegetation.
Yellow starthistle colonizes disturbed sites such as roadsides, overgrazed rangeland and pasture, orchards, and irrigation ditch banks. In the absence of major disturbance, yellow starthistle invaded communities dominated by bluebunch wheatgrass (*Pseudoroegneria spicata*) where site conditions were ideal for yellow starthistle growth.

Seedlings usually emerge in the fall, form rosettes, and begin growing a taproot. Root length after 10 days on a Washington site with cheatgrass averaged 3.7 inches (9.3 cm). In a greenhouse study, root length averaged 6.0 inches (15.2 cm) after 10 days. Root growth continues throughout the winter. In early April in southeastern Washington, taproots of fall germinated yellow starthistle rosettes averaged 11.8 inches (30 cm) in length; the

rosettes were less than 2.4 inches (6 cm) in diameter. By early July, 10_inch (25 cm) tall plants had taproots averaging 30 inches (66 cm).

Occurrence in Park

Yellow starthistle occurs on nearly all of the Idaho park sites.

Potential Damage and Health Concerns

Yellow starthistle is an important rangeland and pasture weed in western North America. It rapidly invades overgrazed rangeland and other disturbed sites. Once established, yellow starthistle is difficult to eradicate. This invasive weed does not present any human health concerns, except for discomfort when the spines pierce clothing. Yellow starthistle can energetically outcompete native vegetation in disturbed areas and drastically alter the historic and cultural scene of areas.

Monitoring and Thresholds

Inspection and monitoring for yellow starthistle will be as follows. On a monthly basis, each site will be traversed to record weed growth and distribution. The locations, relative number or percent of area covered on the ground, and growth stages will be recorded. In addition, all locations where the plants are expanding will be noted. Occurrences of this weed within the park will be the Action Threshold.

Non-chemical Management

Effective control involves a combination of herbicide treatments, biological control agents, and establishment of competitive perennial grasses.

Hand labor is one of the most important means of controlling yellow starthistle if only a very few plants are found on the land. Hand pulling, shovel, or weed digging devices is of best success. Remember, this plant establishes a tap-root and will resprout if not removed. Inconsistent digging and pulling are not useful if the soil contains seeds from the past years. Regular removal of yellow starthistle over a period of approximately ten years will eradicate the weed, unless other seeds are reintroduced.

Well_timed mowing or controlled grazing by cattle can contain large yellow starthistle infestations. Yellow starthistle grows after heavy grazing but produces fewer seeds per plant. Intensive grazing in May and June reduces yellow starthistle size, summer and fall canopy size, and seed production in annual rangeland. Mowing during the early flowering stage minimizes regrowth but plants should be monitored and mowed again if regrowth and flowering occur.

Establishment of perennial grasses after herbicide treatment is necessary to prevent reinvasion by yellow starthistle. Grasses with early growth, strong seedling vigor, and a large root system with good lateral spread have the greatest potential to compete successfully with yellow starthistle. Most authors recommend initially controlling yellow starthistle with herbicides (2, 4-D) while grasses establish, but grass seeding of yellow starthistle_infested sites without initial herbicide treatment has been tested. An infested site in Idaho was disked and seeded with 12 perennial grass species. Only intermediate wheatgrass (*Thinopyrum intermedium ssp. intermedium*), pubescent wheatgrass (*T. intermedium ssp. barbulatum*), and crested wheatgrass *(Agropyron cristatum*) were able to establish. They did not begin to suppress yellow starthistle seed production until their third growing season. Some authors suggest established pubescent wheatgrass may be able to deny resources to yellow starthistle seedlings. Without herbicide control, seeding of orchardgrass (*Dactylis glomerata*) and tall oatgrass (*Arrhenatherum elatius*) did not improve forage on an infested northeastern Oregon site. Fertilizer increased yellow starthistle densities in northeastern Oregon.

Biological control agents which utilize flowerheads have the greatest potential for controlling yellow starthistle. Biota associated with yellow starthistle in southern Europe have been described. Five insects (a gall fly, a seed fly,

and three weevils) have been released in the United States, the first in 1984 and the most recent in 1992. The four earliest released insects are established but their effectiveness is not yet known. A rust fungus is undergoing field testing. Insects, release dates, and establishment information are described.

Most fires probably kill yellow starthistle. Buried seed may germinate after fire, as after other disturbances, if moisture conditions are favorable. The removal of existing vegetation by fire may increase survival of postfire yellow starthistle seedlings by reducing shade. Yellow starthistle may regrow after spring or early summer fire if damage is not severe.

Prescribed fire may be used to control yellow starthistle seed production if plants are burned in the early flowering stage before seed matures. Yellow starthistle is still green prior to seed maturity so there must be adequate dry fuel from other plants for fire to carry.

Chemical Control

Although yellow starthistle can be temporarily controlled with spring herbicide treatments, it establishes from long_lived seed after chemicals have dissipated. In addition, yellow starthistle exhibits a high degree of phenotypic plasticity and may be able to adapt to specific chemical or biological controls.

Herbicide application rates and yellow starthistle susceptibility are described. Picloram_resistant strains of yellow starthistle have recently been observed.

Research efforts on yellow starthistle have been directed primarily on chemical control. Though several chemicals have demonstrated good control of yellow-starthistle, picloram (Tordon) remains the only effective herbicide. Tordon is a restricted use chemical and timing is of utmost importance. Tordon should be applied in early spring when the majority of plants are in a small rosette stage well before bolt. Followup applications are necessary to destroy escaped plants and treatment skips.

Chemicals that have limited success against yellow starthistle are:

Approved Chemical Alternatives at NEPE:

Picloram (Tordon);
Class 40 phenoxyherbicide;
2,4-D (used in pre-treatment of areas in revegetation efforts).

Other chemical alternatives that must have prior approval include:

Resources

Materials Available

Materials available include hand tools (eg. shovels, rakes, pruners, etc.), gloves, and approved chemical treatments.

Technical Experts

NPS-WASO IPM Coordinator, Columbia Cascades Cluster IPM Coordinator, and/or the County Extension Agent for the area.

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Chemical Alternatives and Their Uses

Chemical	Common Name(s)	Use
2,4-Dichlorophenoxyacetic acid; 2,4_D	Aqua Kleen, Demise, Weed_bgone, Weedar_64, Weedone, Class 40A phenoxyherbicide	broadleaf herbicide
acephate; 0, S_dimethyl acetylphosphoramido thioate	Orthene, Tornado	organic phosphate; contact/systemic poison
trichloromonofluore methane dicholofifluoro methane petroleum distillate methylene chloride, pine oil, rotenone, pyrethrins	WaspFreeze, PT-515	killing wasps, hornets, bees, and yellowjackets at the nest
allethrin; d_cis_and/or_ trans_chrysan_themum monocarboxylic acids ester of dl_2_allyl_4_hydroxy_3_ methyl_3_cyclopenten_1_one	Pyrethrin, bioallethrin, Pynamin, Pyrethrains, Sectrol, X_Clude, Pyrenone, Exciter, Kicker, Bio_allethrin, Esbiothrin	contact/stomach/fumigant poisons; space treatment for flying insects
bendiocarb; 2,2_dimethyl_1, 3_benzodioxol_4_y1 methylcarba_mate	Ficam W, Ficam Plus, Ficam G, Turcam	contact/stomach poison; bees, wasps, some roach species (German roaches are resistant)
benzildiethyl methyl ammonium saccharide	Ro-Pel	gustatory inhibitor; woodpeckers, rodents, or other animals
	Big Game Repellent (BGR) and coyote urine	deer and other large animal repellent
borax derivatives	Borste, Tim_Bor, Bora_Care	carpenter ants, termites, and other boring insects
boric acid baits (liquid and solid) and dusts	Roach_Prufe, Roach_Kil, Perma_Dust	ants, roaches, silverfish, and other indoor pests
carbaryl; 1_napthyl methyl carbamate	Sevin	outside pests; carpenter ants, fleas, etc.

Chemical	Common Name(s)	Use
carbon monoxide gas fumigation cartridges	Gopher-Gasser	burrowing rodents
chlorpyrifos; l0,0_diethyl 0_(3,5,6_trichloro_2_pyridyl	Dursban, Empire, Killmaster, Engage, Equity, Duration, Lorsban	carpenter ants in wood; outdoor pests
cholecalciferol	Quintox, Rampage, Vitamin D_3 /Vitamin D_2	outside control of rodents
dalapon	Dalapon	annual grass or perennials in broadleafs
diatomaceous earth dusts with pyrethrins	Diacide D_1O: (pure 9 micron size diatomaceous earth), D_20: (diatomaceous earth, sustained release pyrethrins, and piperonyl butoxide), D_21: (pyrethrins and piperonyl butoxide), Diatect 2D	ants, roaches, silverfish, and other indoor pests
diazinon; O_O_diethyl_0_(2_isopropyl_ 6_methyl_5_ pyrimidinyl	DZN, TKO, Knox Out, Spectracide	outdoor insect pests
dichlorifos/dichloriphos; dimethyl 2,2_dichlorovinyl phosphate	DDVP, Vapona, Vaponite	wasps, hornets, bees, and yellowjackets
diluted ammonia washes	household ammonia	stinging insects disinfectant for cleaning garbage cans to deter wasps, hornets, bees, and yellowjackets
ethylene oxide fumigation		museum fumigation
fenoxycarb (IGR); ethyl-2_(p_phenoxyphenoxy)ethyl	Logic, Ultraban, Regulator, Torus, Pictyl	ants, fleas, roaches, silverfish, etc.
triclopyr; 3,5,6_trichloro_2_pyridyl_ oxyacetic acid	Garlon	black locust, tamarix, sumac, white poplar

Chemical	Common Name(s)	Use
glyphosate	Round-up, Rodeo	vegetation removal
ammonium soaps or higher fatty acids	Hinder	deer repellent
hydramethylnon; amindinohydrazone; tetrahydro_5, (3_(4_(trifluoromthyl) phenyl)_1_(2_(4_(trifluoromethyl) phenyl)_ethenyl)_propenyilidene) hydrazone	Amdro, Combat, Siege, Maxforce	ants, roaches, crickets
hydroprene (IGR); ethyl (2E,4E)_3,7,1 1_trimethyl_2, 4_dodecadienoate	Gencor	roaches, cigarette beetles, etc.
hypochlorite	household bleach	sanitizer
malathion; 0, 0_dimethyl phosphorodithioate ester of diethyl mercaptosuccinate	Cythion, Sumitol, Malathion	outdoor insects
mercaptan		snake repellent
methoprene (IGR); isopropyl (2E,4E)_1 1_meth_oxy_3, 7,11_trimethyl_2,4_ dodecadienoate	Altosid, Dianex, Diacon, Pharorid, Kabata, Precor	fleas, ants, mosquitoes; only affects emerging adults.
methyl bromide fumigation		museum fumigation
mustard oil and capsaicin gustatory repellent		skunk repellent
naphthalene and sulfur		snake repellent
naphthalene repellents		dens and museum cases
o-isopropoxyphenyl methylcarbamate	Baygon	crack/crevice injection for wood destroying insects
paradichlorobenzene repellents	Repel (Leffingwell Chemical, Brea, California)	museum cases

Chemical	Common Name(s)	Use
N, N-diethyl-m-toluamide	DEET (Off, Muskol, Cutters)	personal insect repellents
petroleum oils or specialized mineral oils		suffocates eggs, larvae, and pupae of mosquitoes
potassium salts of fatty acids (soaps)		bee colonies, insects on plants
pyrethrum		contact sprays for fleas, ants, stinging insects; moth proofing
bioresmethrin aerosols and dusts; (5_benzyl_3_furyl) methyl 2,2_dimethyl _3_ (2_methylpropenyl) cyclopropane carboxylate	resmethrin, Scourge, Synthrin	space treatments for honey bees and bumble bees; outside applications; roach populations
	Siduron	annual grass in grass
silica aerogel or silical aerogel with pyrenone	Dri_Die, Tri_Die, Silikil, Drione cuticle from insects	dusting cracks and crevices for insect pests
silica gel		sealant/repellent for cracks
sodium nitrate and charcoal release carbon monoxide		den fumigants
sulfuryl fluoride fumigation		museum fumigation
thiram	Arasan	taste repellent
Picloram; 4,amino_3,5,6_trichloro_ picolinic acid	Tordon	broadleaf herbicide
	triazines	perennial weeds in grass
zinc phosphide	Gopha_rid, ZP Tracking Powder, ZP Bait, Hopkins zinc phosphide	burrowing rodents
	Ziram	fungicide for plant diseases

Appendix C. Emergency Contacts

The following list contains the sheriff, hospitals, and EMS providers in the respective park areas:

Law Enforcement:	
Idaho	
Idaho Co. Sheriff	208/983-1100
Lewis Co. Sheriff	208/937-2447
Nez Perce Co. Sheriff	208/799-3131
Montana	
Beaverhead Co. Sheriff	406/683-2383
Blaine Co. Sheriff	406/357-3170
Oregon	
Oregon State Police	541/426-3036
Hospitals:	
Idaho	
St. Joseph Regional Med. Center, Lewiston	208/743-2511
Tri-State Memorial Hospital, Clarkston	509/758-5511
Syringa General Hospital, Grangeville	208/983-1700
Clearwater Valley Hospital, Orofino	208/476-4555
Montana	
Marcus Daly Mem. Hospital, Hamilton	406/363-2211
Barrett Mem. Hospital, Hamilton	406/683-2323
Northern Montana Hospital, Havre	406/265-2211
Public Health Service, Fort Belnap	406/353-2651
Oregon	
Wallowa County Healthcare, Enterprise	541/426-3111
Ambulance Service - All areas	911
Fire Service - All areas	911
Idaho Emergency Response Commission at	800/632-8000
Montana Disaster and Emergency Services	through the 911 network
Oregon Pesticide Analytical and Response Center	503/731-4025
ChemicalTransportation Emergency Center (CHEMTREC)	800/424-9300
Poison Center	800/541-5624 (Northern Idaho) 800/525-5042 (Montana) 800/452-7165 (Oregon)

Appendix D. Technical/Professional Contacts

IDAHO

State of Idaho:

Department of Fish and Game 1510 Warner Lewiston, ID 83501	208/799-5010
Division of Environmental Quality 1118 F St Lewiston, ID 83501	208/799-4370
Division of Environmental Quality Federal Building Grangeville, ID 83530	208/983-0808

Counties:

Clearwater County Extension Agent 2200 Michigan Orofino, ID 83544	208/476-4434
Idaho County Extension Agent Court House Grangeville, ID 83530	208/983-2667
Nez Perce County Extension Agent 1239 Idaho Lewiston, ID 83501	208/799-3096

MONTANA

State of Montana:

Montana Department of Fish, Wildlife and Parks 730 North Montana Dillon, MT 59725	406/285-3610
Montana Department of Fish, Wildlife and Parks 87 3rd Chinook, MT 59523	406/357-3866
Beaverhead County Weed Supervisor Beaverhead County Courthouse Dillon, MT 59725	406/683-2842
Blaine County Environmental Health Blaine County Courthouse Chinook, MT 59523	406/357-3310

OREGON

State of Oregon:

Oregon Department of Agriculture 635 Capitol Street NE Salem, OR 97310-0110	503/986-4635
Wallowa County Extension Agent 668 Northwest First Enterprise, OR 97828	541/426-3143

NATIONAL PARK SERVICE IPM CONTACTS:

Terry Cacek, WASO-IPM Coordinator National Park Service 1201 Oakridge Dr., Ste 350 Ft. Collins, CO 80525	970/225-3542
Carol DiSalvo, IPM Specialist National Park Service MS 2749 MIB PO Box 37127 Washington DC 20013	202/219-8936
Erv Gasser, CCSO IPM Coordinator National Park Service Columbia Cascades System Support Office 909 First Avenue Seattle, WA 98104-1060	206/220-4263
ChemicalTransportation Emergency Center (CHEMTREC)	800/424-9300

Appendix E. Suppliers

Appendix F. General Bibliography

Centers for Disease Control. 1967. Pictoral Keys to arthropods, reptiles, birds and mammals of public health concern. US Dept. Health, Education, and Welfare. 192 pp.

Hoddenbach, Gerard A. 1996. Integrated Pest Management Plan for Big Bend National Park. PO Box 128, Torrey UT 84775.

National Park Service. 1984. Integrated Pest Management Information Manual, 1st Ed. US Dept. Interior, National Park Service.

National Park Service. 1985. Integrated Pest Management Information Manual, 2nd Ed. US Dept. Interior, National Park Service.

National Park Service. 1985. The Natural Resource Management Guideline, NPS-77. US Dept. Interior, National Park Service.

National Park Service. 1990. Nez Perce National Historical Park: Additions study. US Dept. Interior, National Park Service, Pacific Northwest Region. 66 p.

National Park Service. 1995. Resources Management Plan: Nez Perce National Historical Park Idaho, Montana, Oregon, and Washington. US Dept. Interior, National Park Service, Nez Perce National Historical Park. Unpublished Report. 319 p.

National Park Service. 1996. Draft General Management Plan/Environmental Impact Statement: Nez Perce National Historical Park and Big Hole National Battlefield. US Dept. Interior, National Park Service, Nez Perce National Historical Park. 202 p.

National Park Service. 1996. Integrated Pest Management Information Manual, Internet Ed. US Dept. Interior, National Park Service.

State of Idaho. 1996. Idaho Pesticide Law, Chapter 34, Title 22, Idaho Code. State of Idaho, Department of Agriculture. July 1, 1996.

State of Montana. 1995. Montana Pesticide Act, Title 80, Chapter 8, Sections 80-8-101 through 80-8-405. State of Montana, Department of Agriculture. September 1995.

State of Montana. 1996. Montana Pesticide Act, Administrative Rules, Chapter 10. State of Montana, Department of Agriculture. February 1996.

Appendix G. Compliance (NEPA, NHPA)

Appendix H. Labels/MSDS

Appendix I. Pesticide Approvals

Appendix J. Maps

Included are maps of:
Monitoring Locations
Inspection
Treatments
for

Spalding Site

White Bird Battlefield

Canoe Camp

East Kamiah

Big Hole National Battlefield

Bear Paw Battlefield

Old Chief Joseph Cemetery

Appendix K. Cooperative Agreements

Appendix L. Laws

Included are copies of:

State of Idaho, Department of Agriculture, Idaho Pesticide Law, Chapter 34, Title 22, Idaho Code, July 1, 1996.

State of Montana, Department of Agriculture, Montana Pesticide Act, Title 80, Chapter 8, Sections 80-8-101 through 80-8-405, September 1995.

State of Montana, Department of Agriculture, Montana Pesticide Act, Administrative Rules, Chapter 10, February 1996.

Oregon Revised Statutes, Chapter 634 and Associated Oregon Administrative Rules, Chapter 603, Division 57

Appendix M. CDC Guidelines for Hantavirus

HANTAVIRUS: CDC Guidelines

Tracking a Mystery Disease: a brief history of hantavirus pulmonary syndrome

An outbreak of unexplained illness occurred in May 1993 in the "Four Corners," an area of the Southwest shared by New Mexico, Arizona, Colorado, and Utah. A number of previously healthy young adults suddenly developed acute respiratory symptoms; about half soon died. The New Mexico Department of Health, the Arizona Department of Health Services, the Colorado Department of Health, the Utah Department of Health, the Indian Health Service and CDC, with the assistance of the Navajo Nation Division of Health, rapidly mounted an intensive investigation. Researchers soon suspected that they were dealing with a form of hantavirus, which is transmitted by rodents. Researchers then investigated the possible rodent connection, trapping rodents in the affected area, doing tissue studies both of rodents and hantavirus victims, until the virus and its principal carrierùthe deer mouseùwere positively identified. Why the Four Corners area? Simply because there was a "bumper crop" of rodents there, due to heavy rains during the spring of 1993, which produced an extra_plentiful supply of the foods that rodents eat. Early on, it was also established that person_to_person spread was unlikely. It was also determined that this "new" hantavirus had actually been present, but unrecognized, at least as early as 1959. Since the 1993 outbreak, hantavirus pulmonary syndrome (HPS) has been identified in over half of the states of the U.S. Do you want to learn more details about the discovery of and history of HPS in the United States? Click here for a longer version of the story. Visit HPS Case Information to learn more about the number of cases of the disease that have been reported.

How is hantavirus transmitted?

So just how do people get the hantavirus pulmonary syndrome (HPS)? It all starts with rodents, like the deer mouse and cotton rat, which carry hantaviruses. The basic transmission cycle The short story is that some rodents are infected with a type of hantavirus that causes HPS. In the United States, deer mice (plus cotton rats and rice rats in the southeastern states and the white_footed mouse in the Northeast) are the rodents carrying hantaviruses that cause hantavirus pulmonary syndrome. (Click here to meet the rodents and learn to identify them!) These rodents shed the virus in their urine, droppings and saliva. The virus is mainly transmitted to people when they breathe in air contaminated with the virus. This happens when fresh rodent urine, droppings or nesting materials are stirred up. When tiny droplets containing the virus get into the air, this process is known as " aerosolization."

There are several other ways rodents may spread hantavirus to people: If a rodent with the virus bites them, the virus may be spread this wayùbut this is very rare. Researchers believe that you may be able to get the virus if you touched something that had been contaminated with rodent urine, droppings or saliva, and then touched your nose or mouth. Researchers also suspect that if virus_infected rodent urine, droppings or saliva contaminates food that you eat, you could also become sick. That is another reason why disinfecting rodent_infested areas is so important in preventing transmission of the virus. Transmission can happen anyplace that infected rodents have infested. (Remember, by "carrier rodent" we mean deer mice plus cotton rats and rice rats in the Southeastern states, and the white_footed mouse in the Northeast. Common house mice do not carry hantavirus.) This could be barns or sheds or other outbuildings, warehouses or summer cottages closed up for the season. But carrier rodents infest homes as well! Therefore, the most sensible way to avoid contact with rodents is to prevent rodents from infesting the places where you live and work, and to follow safety precautions if you do stumble into a rodent_infested area. The prevention section of this web site details all of this for you! Could you get the hantavirus from another person? Remember, the types of hantavirus that cause HPS in the United States stop at the person who has been infectedùthey cannot be transmitted from one person to another. For example, you cannot get the virus from touching or kissing a person who has the disease, or from a health care worker who has treated someone with the disease. Finally, you cannot get the virus from a blood transfusion in which the blood came from a person who came down with hantavirus pulmonary syndrome and survived. Could you get hantavirus from animals other than rodents, or from insects? What about pets? Noùresearchers do not believe that the hantaviruses causing HPS are transmitted by any other types of animals

besides rodents. This would include farm animals like cows, chickens or sheep and insects like mosquitoes. Dogs and cats do not carry the virus, but they may bring infected rodents into contact with people if they catch infected rodents and carry them home. Guinea pigs, hamsters, gerbils and other such pets do not carry hantavirus.

Summing up: How hantavirus is transmitted is by exposure to rodent (deer mouse, white-footed mouse, cotton rat, rice rat) rodent saliva/droppings after they dry up, are "aerosolized" and breathed in. There is no evidence of transmission from other people or transmission from other animals or insects.

Who is at Risk of Getting HPS, and Why?

It started in the Southwest, but it's NOT an "Indian disease". You can be old or young, male or female, of any race, living anywhere in almost any part of the Americas. Healthy, active people are more likely to become infected because it's their activities that put them in contact with the virus. By the way, you cannot get HPS from another person.

What kind of activities are risky? Anything that puts you in contact with rodent droppings, urine or nesting materials. That would include such activities as opening up cabins and sheds or cleaning outbuildings that have been closed during the winter such as barns, garages or storage facilities for farm and construction equipment. Both activities mean you may directly touch rodents or their droppings and/or "stir up the dust" and when you touch or inhale them, you're at risk.

Hikers and campers can also be exposed when they use infested trail shelters or camp in other rodent habitats. Construction and utility workers can be exposed when they work in crawl spaces under houses or in vacant buildings that may have a rodent population. Cleaning in and around your own home if rodents have made it their home, too. And many homes can expect to shelter a few rodents, especially when the weather turns cold.

Overall, the chance of being exposed to hantavirus is greatest when people work, play or live in closed spaces where rodents are actively living. But, and this is important: recent research results show that many people who have become ill with HPS got the disease after having been in frequent contact with rodents and/or their droppings for some time. In addition, many people who have become ill reported that they had not seen rodents or their droppingsùat all. Therefore, if you live in an area where the carrier rodents like the deer mouse are known to live, do take sensible precautions before you do activities like those described aboveùeven if you don't see any rodents or their droppings.

Summing up:

Conditions that put you at risk
closed up rooms, cabins, warehouses
housecleaning activities
really stirring up dust
high rodent populationsùso don't invite them to live around you

What Are The Symptoms Of HPS?

The early symptoms. Early symptoms include fatigue, fever and muscle aches, especially the large muscle groupsùthighs, hips, back, sometimes shoulders. These symptoms are universal. There may also be headaches, dizziness, chills and/or abdominal problems, such as nausea, vomiting, diarrhea and abdominal pain. About half of all HPS patients experience these symptoms. How long could it be between the time you get the virus, and the time you start showing these symptoms? Because there have been so few cases of HPS, it isn't quite clear what this "incubation" time" is. However, it appears right now that it may be between one to five weeks after you are exposed to potentially infected rodents and the rodents' droppings before you will show any symptoms. Also remember this: from the data CDC Special Pathogens Branch keeps on all cases reported of HPS, it appears right now that many people who have become ill were in a situation where they didn't see rodents or rodent droppings. Other people have had frequent contact with rodents and their droppings before becoming ill.

This makes pinning down the time when the virus was transmitted very difficult to do.

Late symptoms. 4 - 10 days later. Symptoms include coughing and shortness of breath, with the sensation of, as one survivor put it, a "tight band around my chest and a pillow over my face" as lungs fill with fluid.

What symptoms aren't common? Earache, sore throat and rash are very uncommon.

Summing up:

These are the symptoms of HPS
Early (universal): fever, fatigue, muscle aches
Early (about half): headaches, dizziness, chills, abdominal problems
Late (universal): coughing, shortness of breath

How Do I Prevent HPS?

Eliminate or minimize contact with rodents. Make your home, workplace, vacation home or campsite unattractive to them!

Why is this so important? If rodents don't find that where you are is a good place for them to be, tooùthat means lots of easy-to-get-food and nesting material then you're less likely to come into contact with them. And recent research results show that many people who have become ill with HPS got the disease after having been in frequent contact with rodents and/or their droppings around a home or a workplace. In addition, many people who become ill reported that they had not seen rodents or their droppings at all. Therefore, if you live in an area where the carrier rodents like the deer mouse are known to live, it makes sense to try to keep your home, vacation place, workplace and as far possible, campsite clean.

So, that said, what can you do? The following prevention pages offer tips for preventing hantavirus in all kinds of situations, and explain in detail how to clean up areas where you have found rodents or their droppings.

Tips For Preventing HPS:

Prevention Indoors and Outdoors
Indoors:

Keep a clean home, especially kitchen (wash dishes, clean counters and floor, keep food covered in rodent-proof containers).

Keep tight-fitting lid on garbage, discard uneaten pet food at the end of the day.

Set and keep spring-loaded rodent traps. Set traps near baseboards because rodents tend to run along walls and tight spaces rather than out in the open.

Set EPA-approved rodenticide with bait under plywood or plastic shelter along baseboards. These are sometimes known as "covered bait stations." Remember to follow product use instructions carefully, since rodenticides are poisonous to pets and people, too.

If bubonic plague is a problem in your area, spray flea killer or spread flea powder in the area before setting traps. This is important. If you control rodents but do not control fleas as well, you may increase the risk of infection with bubonic plague, since fleas will leave rodents once the rodents die and will seek out other food sources, including humans.

Seal all entry holes 1/4 inch wide or wider with steel wool, cement, wire screening or other patching materials, inside and out.

Outdoors:

Clear brush, grass and junk from around house foundations to eliminate a source of nesting materials.

Use metal flashing around the base of wooden, earthen or adobe homes to provide a strong metal barrier. Install so that the flashing reaches 12 inches above the ground and six inches down into the ground.

Elevate hay, woodpiles and garbage cans to eliminate possible nesting sites. If possible, locate them 100 feet or more from your house.

Trap rodents outside, too. Poisons or rodenticides may be used as well, but be sure to keep them out of the reach of children or pets.

Encourage natural predators such as non_poisonous snakes, owls and hawks.

Remember, totally getting rid of all rodents isn't feasible, but with ongoing effort you can keep the population very low.

Clean up infested areas, using safety precautions:

Put on latex rubber gloves before cleaning up.

Don't stir up dust by sweeping up or vacuuming up droppings, urine or nesting materials.

Instead, thoroughly wet contaminated areas with detergent or liquid to deactivate the virus. Most general purpose disinfectants and household detergents are effective. However, a hypochlorite solution prepared by mixing 1 and 1/2 cups of household bleach in 1 gallon of water may be used in place of commercial disinfectant. When using the chlorine solution, avoid spilling the mixture on clothing or other items that may be damaged.

Once everything is wet, take up contaminated materials with a damp towel, then mop or sponge the area with disinfectant.

Spray dead rodents with disinfectant, then double_bag along with all cleaning materials and bury or burnùor throw out in appropriate waste disposal system. If burning or burying isn't fesible, contact your local or state health department about other disposal methods.

Finally, disinfect gloves before taking them off with disinfectant or soap and water. After taking off the clean gloves, thoroughly wash hands with soap and warm water.
When going into cabins or outbuildings (or work areas) that have been closed for awhile, open them up and air out before cleaning.

What if my house or workplace is heavily infested with rodents? You should get help from a professional exterminator if you see lots of droppings or rodentsùyou may have a bad infestation problem. Or you can contact your local health authorities for advice. CDC has recommendations for how heavy infestations may most safely be handled.

Why all the fuss about spraying disinfectant, washing traps with bleach, and such?

These viruses are surrounded by a lipid (fatty) envelope, so they are somewhat fragile. The lipid envelope can be destroyed and the virus killed by fat solvents like alcohol, ordinary disinfectants and household bleach. That is why one of the most important ways to prevent transmitting the disease is to carefully wet down dead rodents

and areas where rodents have been with disinfectant and/or bleach. When you do this, you are killing the virus itself and reducing the chance that the virus will get into the air.

Summing up:

How to prevent HPS:

make your home, workplace, vacation home unattractive to them
clean up infested areas using safety precautions
wet down infested areas with bleach/disinfectant to kill the virus before it aerosolizes
in other words: AIR OUT, SEAL UP, TRAP UP, CLEAN UP

Precautions for Workers in Affected Areas Who are Regularly Exposed to Rodents

Persons who frequently handle or are exposed to rodents (e.g., mammalogists, pest_control workers) in the affected area are probably at higher risk for hantavirus infection than the general public because of their frequency of exposure. Therefore, enhanced precautions are warranted to protect them against hantavirus infection.

Precautions To Be Used:

A baseline serum sample, preferably drawn at the time of employment, should be available for all persons whose occupations involve frequent rodent contact. The serum sample should be stored at $-20^{O}C$.

Workers in potentially high_risk settings should be informed about the symptoms of the disease and be given detailed guidance on prevention measures.

Workers who develop a febrile or respiratory illness within 45 days of the last potential exposure should immediately seek medical attention and inform the attending physician of the potential occupational risk of hantavirus infection. The physician should contact local health authorities promptly if hantavirus_associated illness is suspected. A blood sample should be obtained and forwarded with the baseline serum through the state health department to CDC for hantavirus antibody testing.

Workers should wear a half-face air-purifying (or negative-pressure) respirator or PAPR equipped with HEPA filters when removing rodents from traps or handling rodents in the affected area. Respirators (including positive-pressure types) are not considered protective if facial hair interferes with the face seal, since proper fit cannot be assured. Respirator use practices should be in accord with a comprehensive user program and should be supervised by a knowledgeable person. Workers should wear rubber or plastic gloves when handling rodents or handling traps containing rodents. Gloves should be washed and disinfected before removing them, as described above.

Traps contaminated by rodent urine or feces or in which a rodent was captured should be disinfected with a commercial disinfectant or bleach solution. Dispose of dead rodents as described in the section on Eliminating Rodents inside the Home.

Persons removing organs or obtaining blood from rodents in affected areas should contact the Special Pathogens Branch, Division of Viral and Rickettsial Diseases, National Center for Infectious Diseases, Centers for Disease Control and Prevention, [telephone (404) 639_1115] for detailed safety precautions.

Precautions for Other Occupational Groups Who Have Potential Rodent Contact

Insufficient information is available at this time to allow general recommendations regarding risks or precautions for persons in the affected areas who work in occupations with unpredictable or incidental contact with rodents or their habitations. Examples of such occupations include telephone installers, maintenance workers, plumbers, electricians, and certain construction workers. Workers in these jobs may have to enter various buildings, crawl spaces, or other sites that may be rodent infested. Recommendations for such circumstances must be made on a case-by-case basis after the specific working environment has been assessed and state or local health departments have been consulted.

Precautions for Campers and Hikers in the Affected Areas

There is no evidence to suggest that travel into areas where HPS has been reported should be restricted. Most usual tourist activities pose little or no risk that travelers will be exposed to rodents or their urine and/or droppings.

However, persons who do outdoor activities such as camping or hiking in areas where the disease has been reported should take precautions to reduce the likelihood of their exposure to potentially infectious materials.

Useful Precautions:

Avoid coming into contact with rodents and rodent burrows or disturbing dens (such as pack rat nests).

Air, then disinfect cabins or shelters before using them. These places often shelter rodents.

Do not pitch tents or place sleeping bags in areas in proximity to rodent droppings or burrows or near areas that may shelter rodents or provide food for them (e.g., garbage dumps or woodpiles).

If possible, do not sleep on the bare ground. In shelters, use a cot with the sleeping surface at least 12 inches above the ground. Use tents with floors or a ground cloth if sleeping in the open air.

Keep food in rodent-proof containers!

Promptly bury (or preferably burn followed by burying, when in accordance with local requirements) all garbage and trash, or discard in covered trash containers.

Use only bottled water or water that has been disinfected by filtration, boiling, chlorination, or iodination for drinking, cooking, washing dishes, and brushing teeth.

And last but not least, do not play with or handle any rodents that show up at the camping or hiking site, even if they appear friendly.

What Is The Treatment For HPS?

At the present time, there is no specific treatment for the hantavirus infection. However, we do know that if the infected individuals are recognized early and are taken to an intensive care unit, some patients may do better. In intensive care, patients are intubated and given oxygen therapy to help them through the period of severe respiratory distress.

The earlier the patient is brought in to intensive care, the better. If a patient is experiencing full distress, it is less likely the treatment will be effective.

Therefore if you have been around rodents and have symptoms of fever, deep muscle aches and severe shortness of breath, see your doctor immediately. Be sure to tell your doctor that you have been around rodents

this will alert your physician to look closely for any rodent-carried disease such as HPS.

1998, The Centers for Disease Control and Prevention (CDC)